Chapter 2, Problem 1.

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

Chapter 2, Solution 1

v = iR   i = v/R = (16/5) mA = **<u>3.2 mA</u>**

Chapter 2, Problem 2.

Find the hot resistance of a lightbulb rated 60 W, 120 V.

Chapter 2, Solution 2

p = v^2/R → **R** = v^2/p = 14400/60 = **<u>240 ohms</u>**

Chapter 2, Problem 3.

A bar of silicon is 4 cm long with a circular cross section. If the resistance of the bar is 240 Ω at room temperature, what is the cross-sectional radius of the bar?

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 = **<u>0.1843 m</u>**

Chapter 2, Problem 4.

(a) Calculate current *i* in Fig. 2.68 when the switch is in position 1.
(b) Find the current when the switch is in position 2.

Chapter 2, Solution 4

(a) **i** = 3/100 = **<u>30 mA</u>**
(b) **i** = 3/150 = **<u>20 mA</u>**

Chapter 2, Problem 5.

For the network graph in Fig. 2.69, find the number of nodes, branches, and loops.

Chapter 2, Solution 5

$n = 9; \quad l = 7; \ \mathbf{b} = n + l - 1 = \underline{\mathbf{15}}$

Chapter 2, Problem 6.

In the network graph shown in Fig. 2.70, determine the number of branches and nodes.

Chapter 2, Solution 6

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

Chapter 2, Problem 7.

Determine the number of branches and nodes in the circuit of Fig. 2.71.

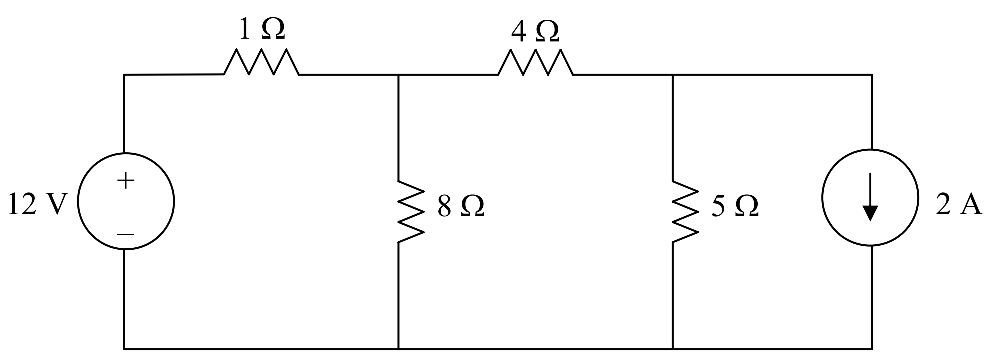


Figure 2.71 For Prob. 2.7.

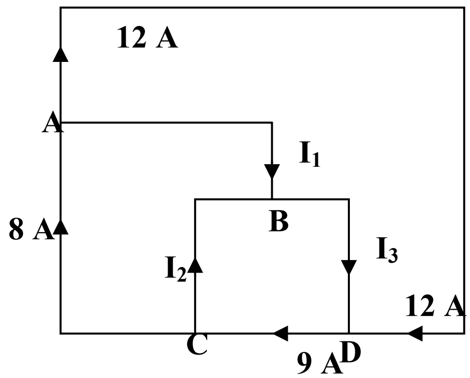
Chapter 2, Solution 7

6 branches and 4 nodes.

Chapter 2, Problem 8.

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

Chapter 2, Solution 8



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, Problem 9.

Find i_1, i_2, and i_3 in Fig. 2.73.

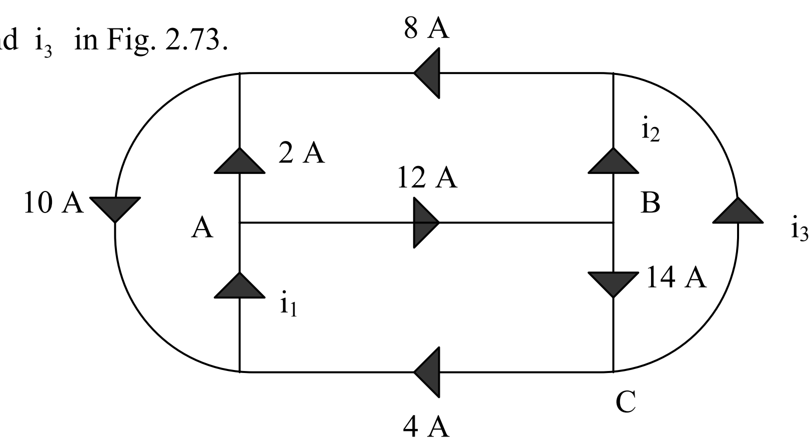


Figure 2.73 For Prob. 2.9.

Chapter 2, Solution 9

At A, $2 + 12 = i_1 \longrightarrow i_1 = \underline{14\text{ A}}$

At B, $12 = i_2 + 14 \longrightarrow i_2 = \underline{-2\text{ A}}$

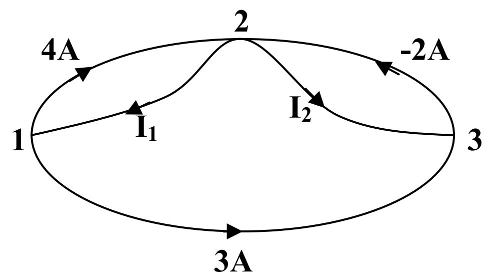
At C, $14 = 4 + i_3 \longrightarrow i_3 = \underline{10\text{ A}}$

Chapter 2, Problem 10.

In the circuit in Fig. 2.67 decrease in R_3 leads to a decrease of:

(a) current through R_3
(b) voltage through R_3
(c) voltage across R_1
(d) power dissipated in R_2
(e) none of the above

Chapter 2, Solution 10



At node 1, $4 + 3 = i_1 \longrightarrow$ $\underline{i_1 = 7A}$
At node 3, $3 + i_2 = -2 \longrightarrow$ $\underline{i_2 = -5A}$

Chapter 2, Problem 11.

In the circuit of Fig. 2.75, calculate V_1 and V_2.

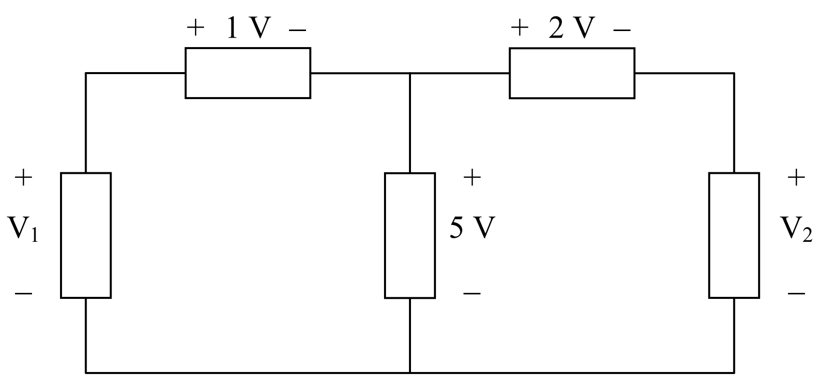


Figure 2.75 For Prob. 2.11.

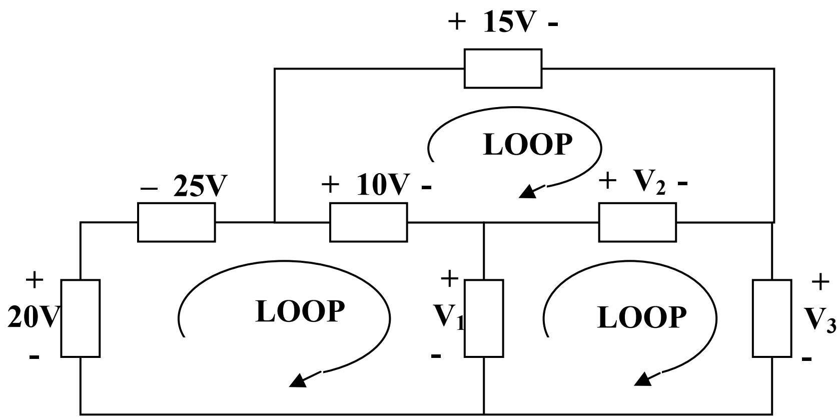
Chapter 2, Solution 11

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

Chapter 2, Problem 12.

In the circuit in Fig. 2.76, obtain v_1, v_2, and v_3.

Chapter 2, Solution 12



For loop 1, $-20 -25 +10 + v_1 = 0 \longrightarrow$ $\underline{\mathbf{v_1 = 35v}}$

For loop 2, $-10 +15 -v_2 = 0 \longrightarrow$ $\underline{\mathbf{v_2 = 5v}}$

For loop 3, $-V_1 + V_2 + V_3 = 0 \longrightarrow$ $\underline{\mathbf{v_3 = 30v}}$

Chapter 2, Problem 13.

For the circuit in Fig. 2.77, use KCL to find the branch currents I_1 to I_4.

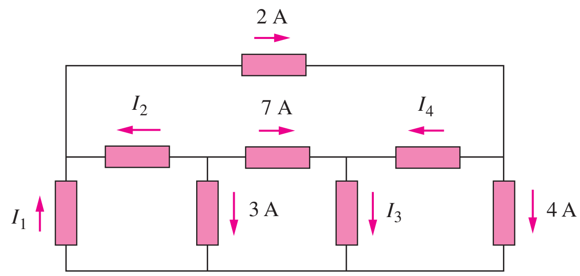
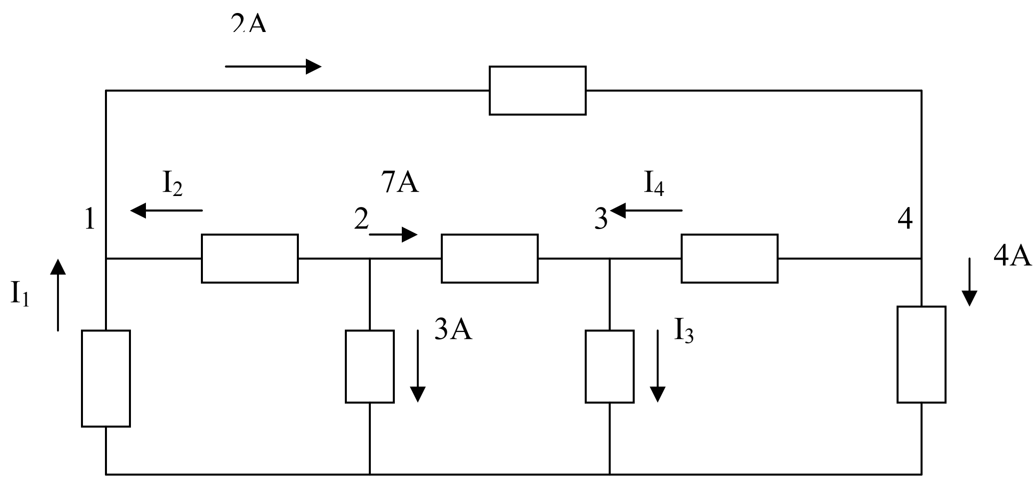


Figure 2.77

Chapter 2, Solution 13



At node 2,

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

At node 1,

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

At node 4,

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

At node 3,

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

Hence,

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

Chapter 2, Problem 14.

Given the circuit in Fig. 2.78, use KVL to find the branch voltages V_1 to V_4.

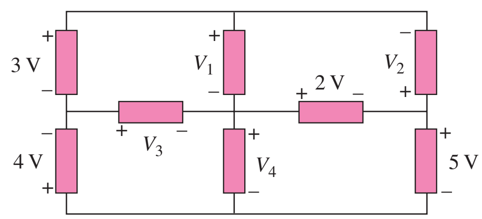
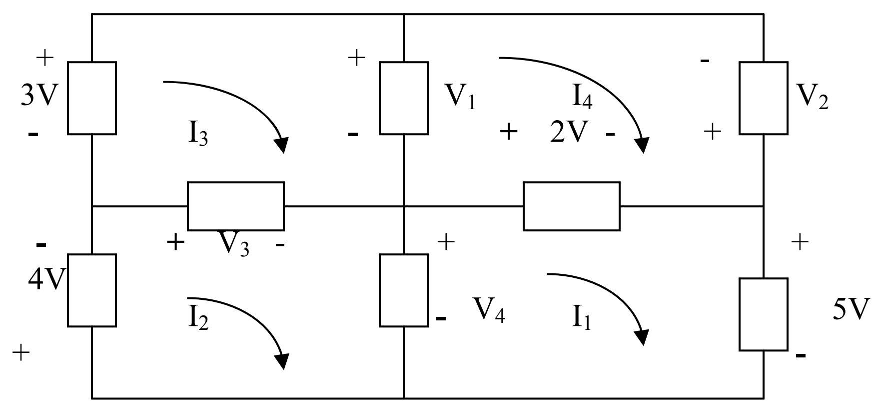


Figure 2.78

Chapter 2, Solution 14



For mesh 1,

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

For mesh 2,

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

For mesh 3,

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

For mesh 4,

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

Thus,

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

Chapter 2, Problem 15.

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

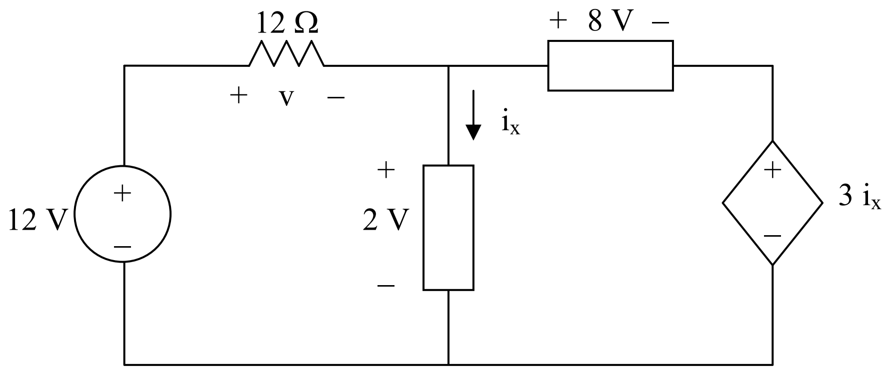


Figure 2.79 For Prob. 2.15.

Chapter 2, Solution 15

For loop 1, $-12 + v + 2 = 0$, $v =$ **10 V**

For loop 2, $-2 + 8 + 3i_x = 0$, $i_x =$ **–2 A**

Chapter 2, Problem 16.

Determine V_o in the circuit in Fig. 2.80.

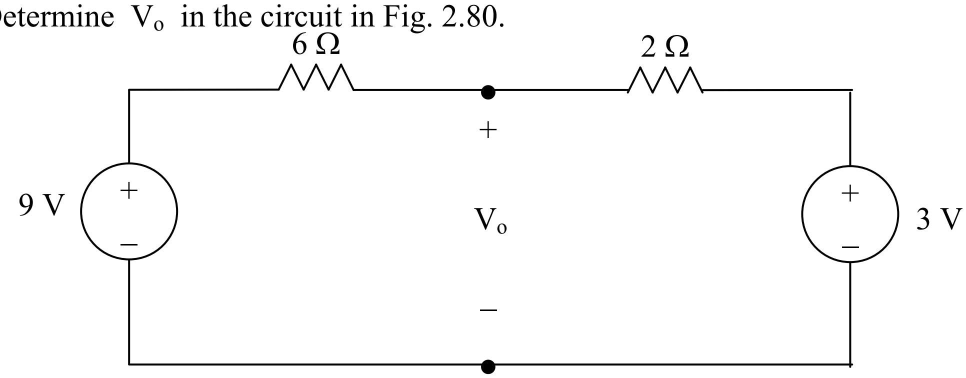


Figure 2.80 For Prob. 2.16.

Chapter 2, Solution 16

Apply KVL,

$-9 + (6+2)I + 3 = 0$, $8I = 9-3=6$, $I = 6/8$

Also,

$-9 + 6I + V_o = 0$

$V_o = 9- 6I =$ **4.5 V**

Chapter 2, Problem 17.

Obtain v_1 through v_3 in the circuit in Fig. 2.78.

Chapter 2, Solution 17

Applying KVL around the entire outside loop we get,

$$-24 + v_1 + 10 + 12 = 0 \text{ or } v_1 = \underline{\mathbf{2V}}$$

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

$$v_2 + 10 + 12 = 0 \text{ or } v_2 = \underline{\mathbf{-22V}}$$

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

$$-v_3 + 10 = 0 \text{ or } v_3 = \underline{\mathbf{10V}}$$

Chapter 2, Problem 18.

Find I and V_{ab} in the circuit of Fig. 2.79.

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, Problem 19.

From the circuit in Fig. 2.80, find *I*, the power dissipated by the resistor, and the power supplied by each source.

Chapter 2, Solution 19

APPLYING KVL AROUND THE LOOP, WE OBTAIN

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

Power dissipated by the resistor:

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

Power supplied by the sources:

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

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

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

Chapter 2, Problem 20.

Determine i_o in the circuit of Fig. 2.81.

Chapter 2, Solution 20

APPLYING KVL AROUND THE LOOP,

$-36 + 4i_0 + 5i_0 = 0 \longrightarrow \underline{\mathbf{i_0 = 4A}}$

Chapter 2, Problem 21.

Find V_x in the circuit of Fig. 2.85.

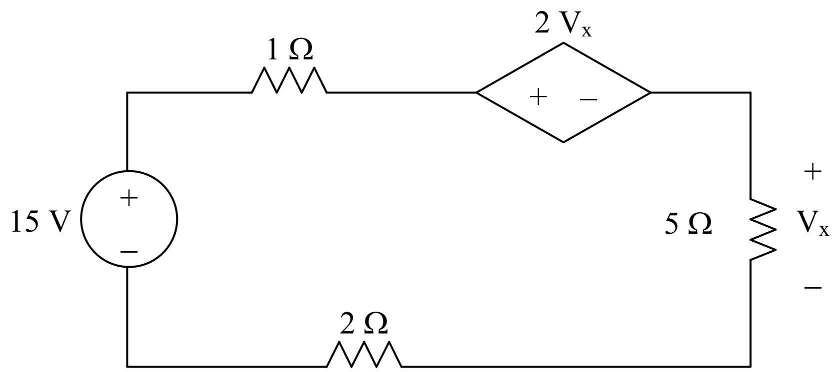


Figure 2.85 For Prob. 2.21.

Chapter 2, Solution 21

Applying KVL,

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

But $V_x = 5I$,

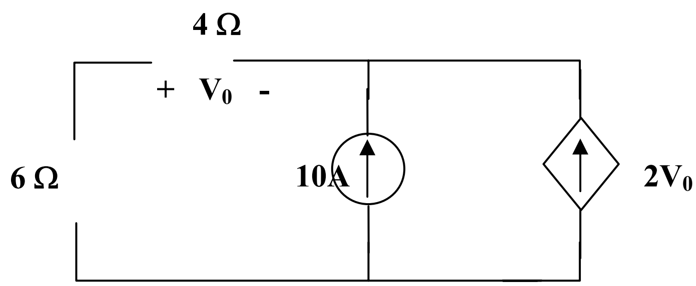
$$-15 + 8I + 10I = 0, \qquad I = 5/6$$

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

Chapter 2, Problem 22.

Find V_o in the circuit in Fig. 2.85 and the power dissipated by the controlled source.

Chapter 2, Solution 22



At the node, KCL requires that

$$\frac{v_0}{4} + 10 + 2v_0 = 0 \longrightarrow \quad v_0 = \underline{\mathbf{-4.444V}}$$

The current through the controlled source is

$$i = 2V_0 = -8.888\text{A}$$

and the voltage across it is

$$v = (6 + 4)\ i_0\ (\text{where } i_0 = v_0/4) = 10\frac{v_0}{4} = -11.111$$

Hence,

$$p_2\ v_i = (-8.888)(-11.111) = \underline{\mathbf{98.75\ W}}$$

Chapter 2, Problem 23.

In the circuit shown in Fig. 2.87, determine v_x and the power absorbed by the 12-Ω resistor.

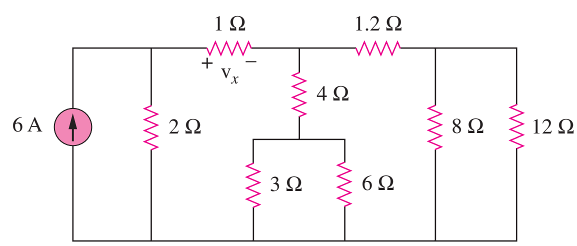
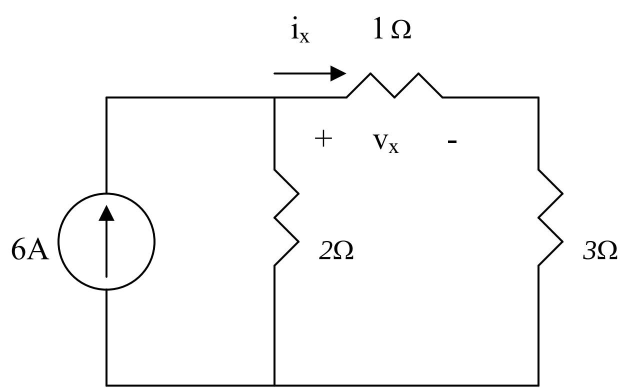


Figure 2.87

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,

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

The current through the 1.2-Ω resistor is $0.5i_x$ = 1A. The voltage across the 12-Ω resistor is 1 x 4.8 = 4.8 V. Hence the power is

$$p = \frac{v^2}{R} = \frac{4.8^2}{12} = \underline{1.92W}$$

Chapter 2, Problem 24.

For the circuit in Fig. 2.86, find V_o / V_s in terms of α, R_1, R_2, R_3, and R_4. If $R_1 = R_2 = R_3 = R_4$, what value of α will produce | V_o / V_s | = 10?

Chapter 2, Solution 24

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

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

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

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

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

Chapter 2, Problem 25.

For the network in Fig. 2.88, find the current, voltage, and power associated with the 20-kΩ resistor.

Chapter 2, Solution 25

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

Using current division,

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

$V_{20} = 20 \times 0.1$ kV = **<u>2 kV</u>**

$p_{20} = I_{20} V_{20}$ = **<u>0.2 kW</u>**

Chapter 2, Problem 26.
For the circuit in Fig. 2.90, i_o =2 A. Calculate i_x and the total power dissipated by the circuit.

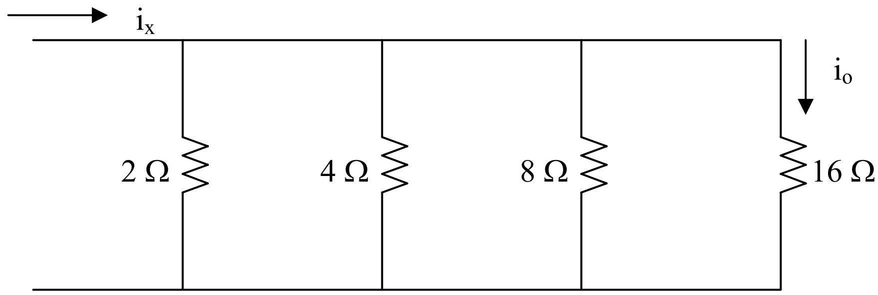


Figure 2.90 For Prob. 2.26.

Chapter 2, Solution 26

If i_{16}= i_o = 2A, then v = 16x2 = 32 V

$$i_8 = \frac{v}{8} = 4\text{ A}, \quad i_4 = \frac{v}{4} = 8\text{ A}, \qquad \text{i}_2 = \frac{v}{2} = 16$$

$$i_x = i_2 + i_4 + i_8 + i_{16} = 16+8+4+2 = \underline{30\text{ A}}$$

$$P = \sum i^2 R = 16^2 x2 + 8^2 x4 + 4^2 x8 + 2^2 x16 = 960\text{ W}$$

or

$$P = i_x v = 30x32 = \underline{960\text{ W}}$$

Chapter 2, Problem 27.
Calculate V_o in the circuit of Fig. 2.91.

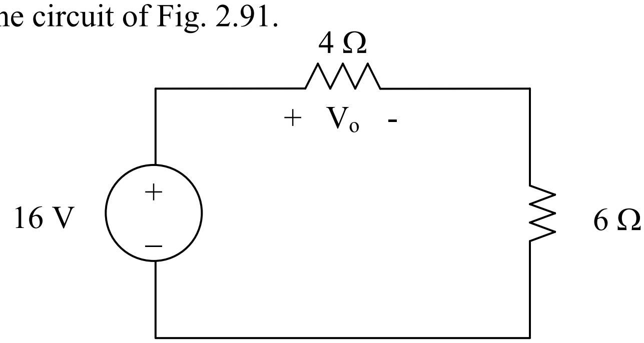


Figure 2.91 For Prob. 2.27.

Chapter 2, Solution 27
Using voltage division,

$$V_o = \frac{4}{4+16}(16\text{V}) = \underline{6.4\text{ V}}$$

Chapter 2, Problem 28.

Find v_1, v_2, and v_3 in the circuit in Fig. 2.91.

Chapter 2, Solution 28

We first combine the two resistors in parallel

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

We now apply voltage division,

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

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

Hence, $v_1 = \underline{\mathbf{28\ V}}$, $v_2 = \underline{\mathbf{12\ V,}}$ $v_s = \underline{\mathbf{12\ V}}$

Chapter 2, Problem 29.

All resistors in Fig. 2.93 are 1 Ω each. Find R_{eq}.

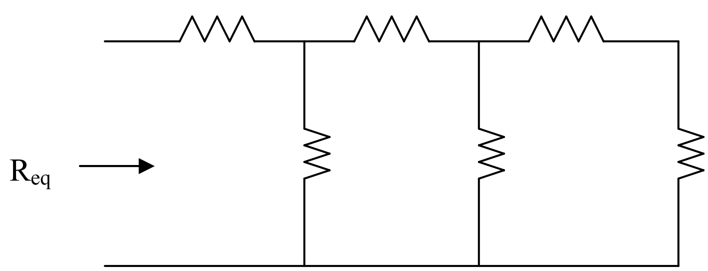


Figure 2.93 For Prob. 2.29.

Chapter 2, Solution 29

$$R_{eq} = 1 + 1//(1 + 1//2) = 1 + 1//(1+ 2/3) =1+ 1//5/3 = \underline{\mathbf{1.625\ \Omega}}$$

Chapter 2, Problem 30.

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

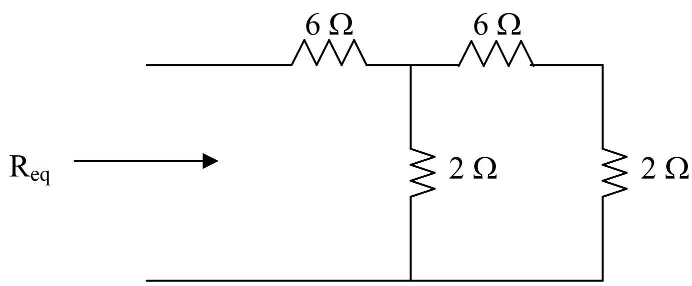


Figure 2.94 For Prob. 2.30.

Chapter 2, Solution 30

We start by combining the 6-ohm resistor with the 2-ohm one. We then end up with an 8-ohm resistor in parallel with a 2-ohm resistor.

$$(2x8)/(2+8) = 1.6\ \Omega$$

This is in series with the 6-ohm resistor which gives us,

$$R_{eq} = 6+1.6 = \underline{\mathbf{7.6\ \Omega}}.$$

Chapter 2, Problem 31.

For the circuit in Fig. 2.95, determine i_1 to i_5.

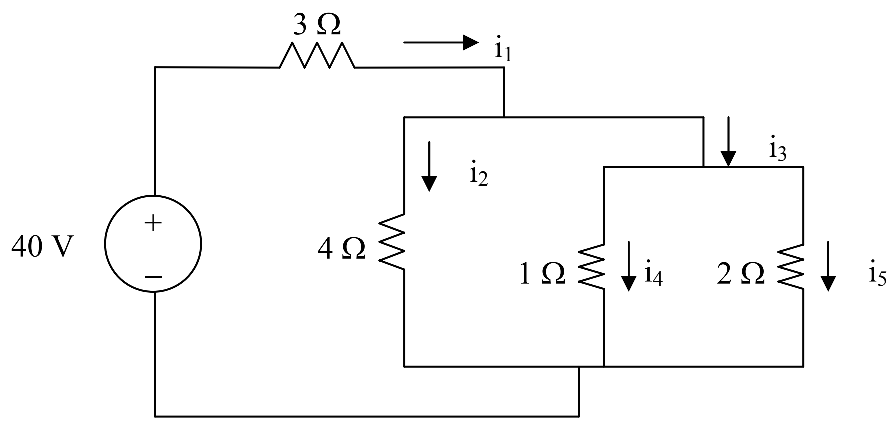


Figure 2.95 For Prob. 2.31.

Chapter 2, Solution 31

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

$$i_1 = \frac{40}{3.5714} = \underline{11.2 \text{ A}}$$

$$v_1 = 0.5714 x i_1 = 6.4\text{V}, \quad i_2 = \frac{v_1}{4} = \underline{1.6 \text{ A}}$$

$$i_4 = \frac{v_1}{1} = \underline{6.4 \text{ A}}, \quad i_5 = \frac{v_1}{2} = \underline{3.2 \text{ A}}, \quad i_3 = i_4 + i_5 = \underline{9.6 \text{ A}}$$

Chapter 2, Problem 32.

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

Chapter 2, Solution 32

We first combine resistors in parallel.

$$20\|30 = \frac{20x30}{50} = 12\ \Omega$$

$$10\|40 = \frac{10x40}{50} = 8\ \Omega$$

Using current division principle,

$$i_1 + i_2 = \frac{8}{8+12}(20) = 8A, i_3 + i_4 = \frac{12}{20}(20) = 12A$$

$$i_1 = \frac{20}{50}(8) = \underline{\mathbf{3.2\ A}}$$

$$i_2 = \frac{30}{50}(8) = \underline{\mathbf{4.8\ A}}$$

$$i_3 = \frac{10}{50}(12) = \underline{\mathbf{2.4A}}$$

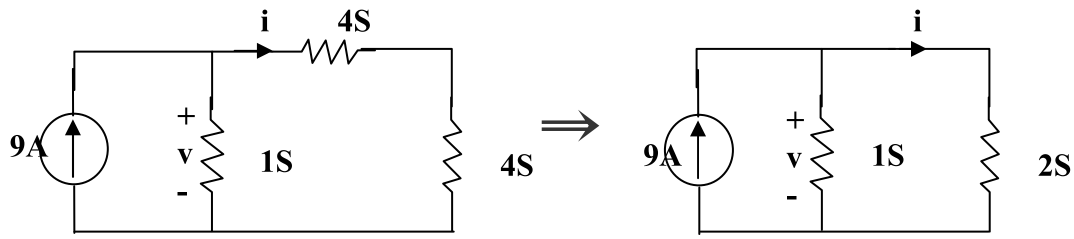
$$i_4 = \frac{40}{50}(12) = \underline{\mathbf{9.6\ A}}$$

Chapter 2, Problem 33.

Obtain *v* and *i* in the circuit in Fig. 2.97.

Chapter 2, Solution 33

Combining the conductance leads to the equivalent circuit below



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

Using current division,

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

Chapter 2, Problem 34.

Using series/parallel resistance combination, find the equivalent resistance seen by the source in the circuit of Fig. 2.98. Find the overall dissipated power.

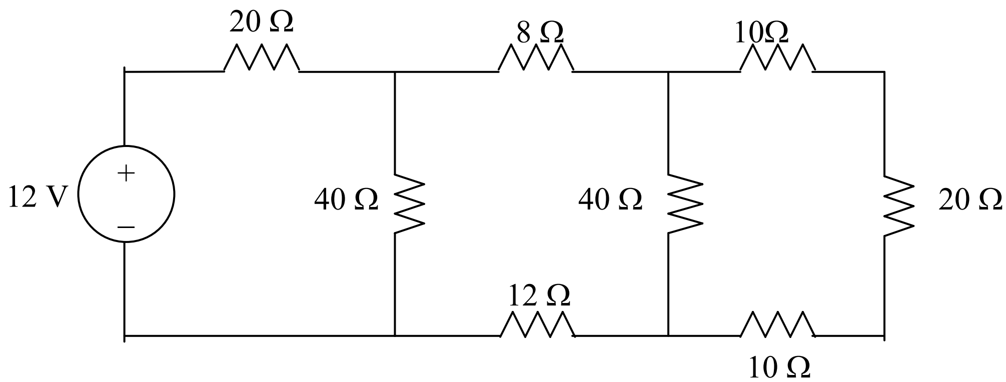


Figure 2.98 For Prob. 2.34.

Chapter 2, Solution 34

40//(10 + 20 + 10)= 20 Ω,
40//(8+12 + 20) = 20 Ω

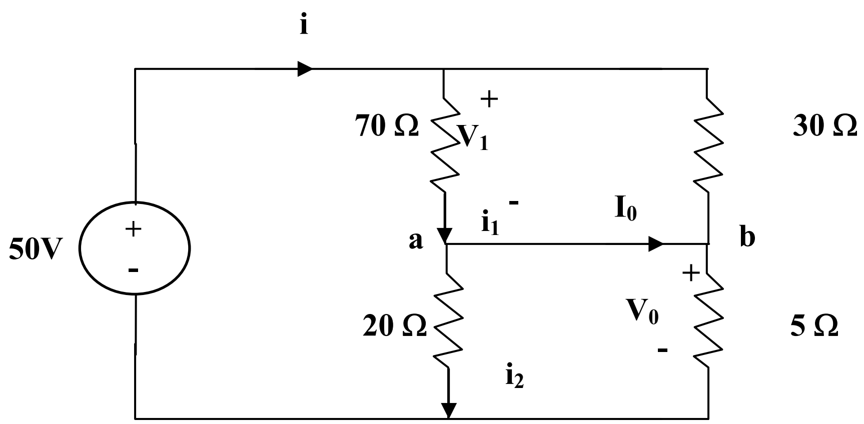
$$R_{eq} = 20 + 20 = \underline{40\ \Omega}$$

$$I = \frac{V}{R_{eq}} = 12/40, \qquad P = VI = \frac{12^2}{40} = \underline{3.6\ \text{W}}$$

Chapter 2, Problem 35.

Calculate V_o and I_o in the circuit of Fig. 2.99.

Chapter 2, Solution 35



Combining the versions in parallel,

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

$$i = \frac{50}{21+4} = 2\ \text{A}$$

$v_i = 21i = 42$ V, $v_0 = 4i = 8$ V

$i_1 = \frac{v_1}{70} = 0.6$ A, $i_2 = \frac{v_2}{20} = 0.4$ A

At node a, KCL must be satisfied

$$i_1 = i_2 + I_0 \longrightarrow 0.6 = 0.4 + I_0 \longrightarrow I_0 = 0.2\ \text{A}$$

Hence $v_0 =$ **8 V** and $I_0 =$ **0.2A**

Chapter 2, Problem 36.

Find i and V_o in the circuit of Fig. 2.100.

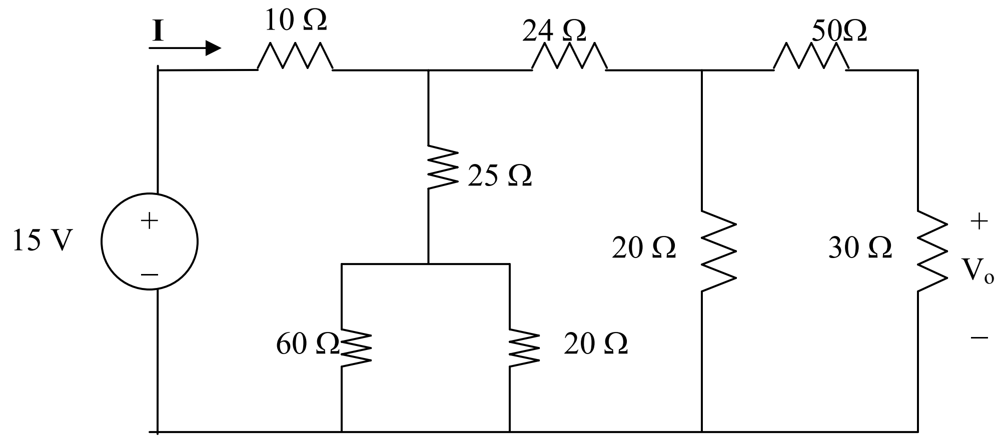


Figure 2.100 For Prob. 2.36.

Chapter 2, Solution 36

$$20//(30+50) = 16, \quad 24 + 16 = 40, \quad 60//20 = 15$$

$$R_{eq} = 10 + (15 + 25) // 40 = 10 + 20 = 30$$

$$i = \frac{v_s}{R_{eq}} = \frac{15}{30} = \underline{0.5\text{ A}}$$

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

$$i_1 = \frac{40}{40+40} i = 0.25\text{ A}, \qquad i_o = \frac{20}{20+80} i_1 = 0.05\text{ A}$$

$$v_o = 30 i_o = 30x0.05 = \underline{1.5\text{ V}}$$

Chapter 2, Problem 37.

Find R for the circuit in Fig. 2.101.

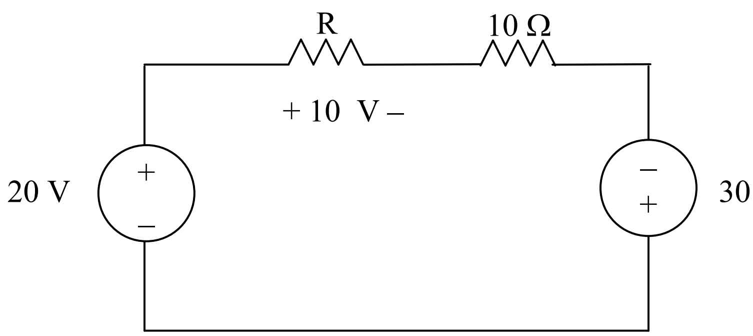


Figure 2.101 For Prob. 2.37.

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, Problem 38.

Find R_{eq} and i_o in the circuit of Fig. 2.102.

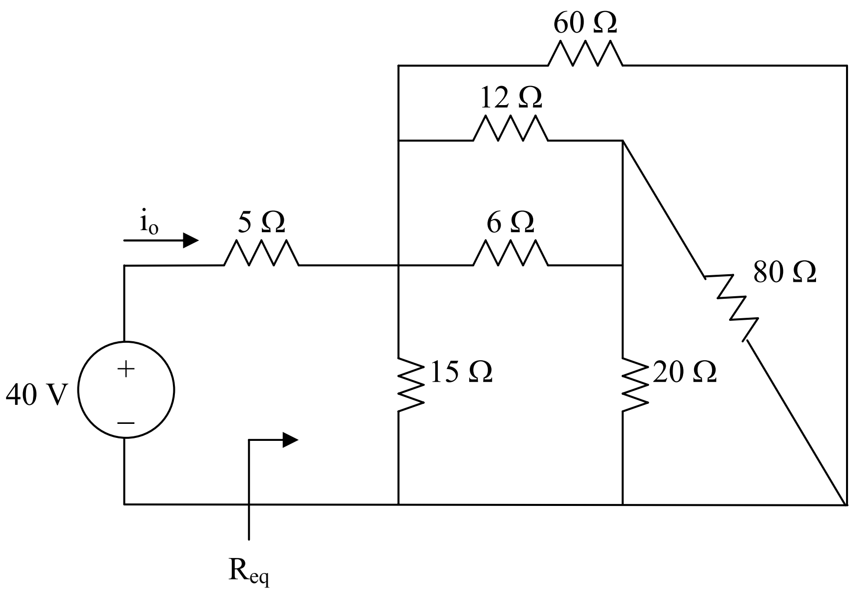
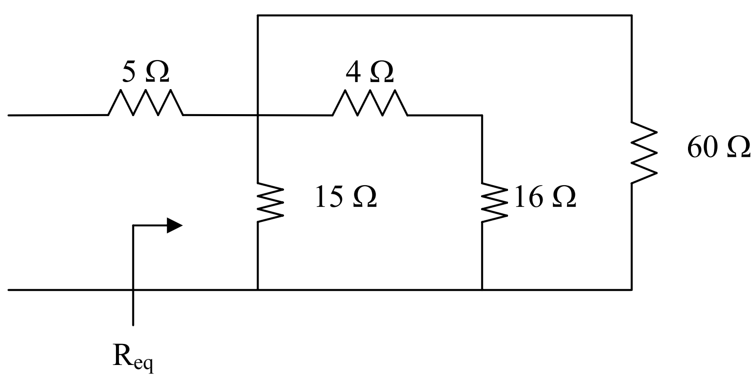


Figure 2.102 For Prob. 2.38

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
$R_{eq} = 15 // 15 + 5 = \underline{12.5\ \Omega}$

$$i_o = \frac{40}{R_{eq}} = \underline{3.2\ \text{A}}$$

Chapter 2, Problem 39.

Evaluate R_{eq} for each of the circuits shown in Fig. 2.103.

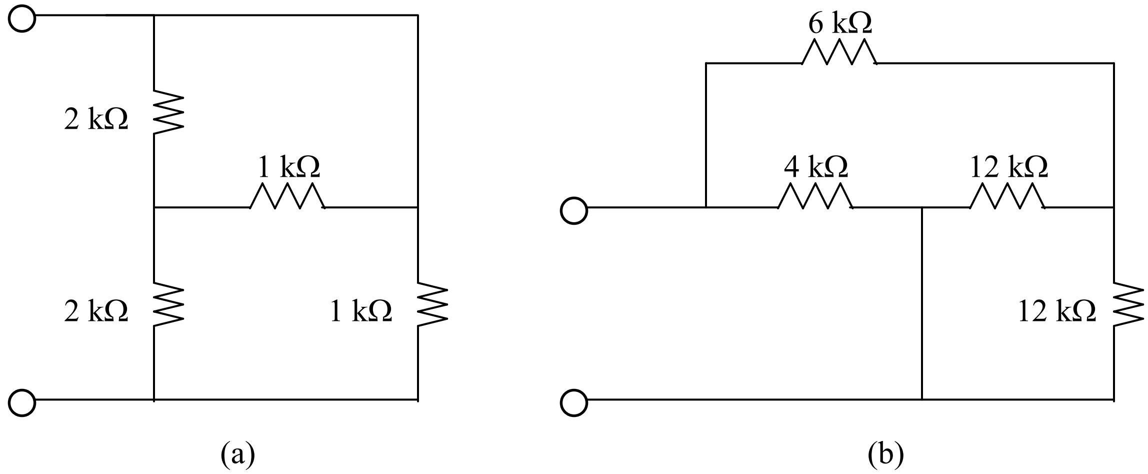


Figure 2.103 For Prob. 2.39.

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,

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

(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,

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

Chapter 2, Problem 40.

For the ladder network in Fig. 2.104, find I and R_{eq}.

Chapter 2, Solution 40

$$\text{REQ} = 3 + 4 \| (2 + 6 \| 3) = 3 + 2 = \underline{5\Omega}$$

$$I = \frac{10}{\text{Req}} = \frac{10}{5} = \underline{\mathbf{2\ A}}$$

Chapter 2, Problem 41.

If R_{eq} = 50 Ω in the circuit in Fig. 2.105, find *R*.

Chapter 2, Solution 41

Let R_0 = combination of three 12Ω resistors in parallel

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

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

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

or R = **16 Ω**

Chapter 2, Problem 42.

Reduce each of the circuits in Fig. 2.106 to a single resistor at terminals *a*-*b*.

Chapter 2, Solution 42

(a) $R_{ab} = 5 \| (8 + 20 \| 30) = 5 \| (8 + 12) = \frac{5x20}{25} = \mathbf{4\ \Omega}$

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

Chapter 2, Problem 43

Calculate the equivalent resistance R_{ab} at terminals *a-b* for each of the circuits in Fig.2.107.

Chapter 2, Solution 43

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

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

$$R_{ab} = 80\|(10+10) = \frac{80+20}{100} = \underline{\mathbf{16\ \Omega}}$$

Chapter 2, Problem 44.

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

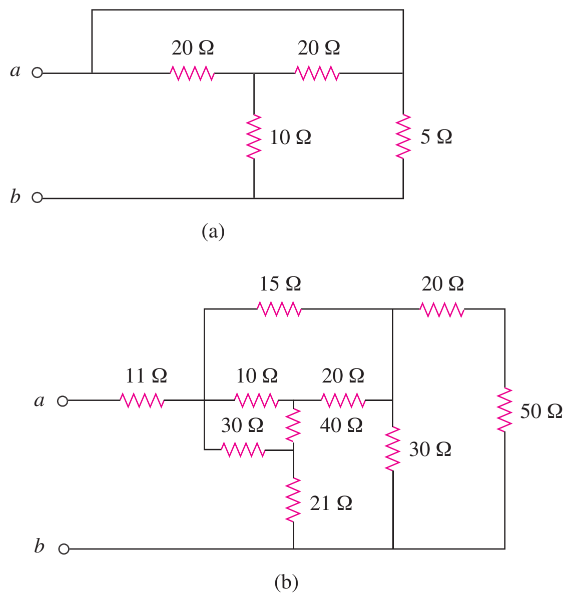


Figure 2.108

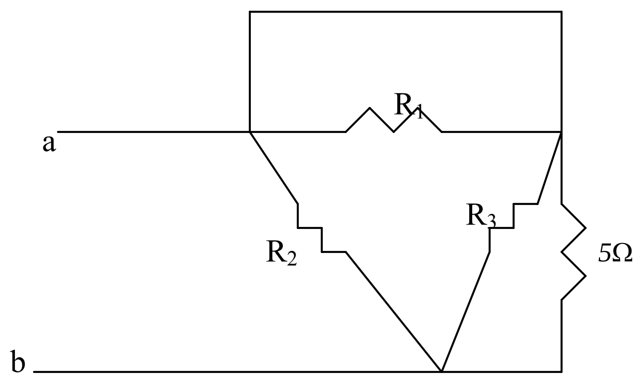
Chapter 2, Solution 44

(a) Convert T to Y and obtain

$$R_1 = \frac{20x20 + 20x10 + 10x20}{10} = \frac{800}{10} = 80\Omega$$

$$R_2 = \frac{800}{20} = 40\Omega = R_3$$

The circuit becomes that shown below.



$R_1//0 = 0$, $R_3//5 = 40//5 = 4.444\,\Omega$

$R_{ab} = R_2 // (0 + 4.444) = 40 // 4.444 = \underline{4\Omega}$

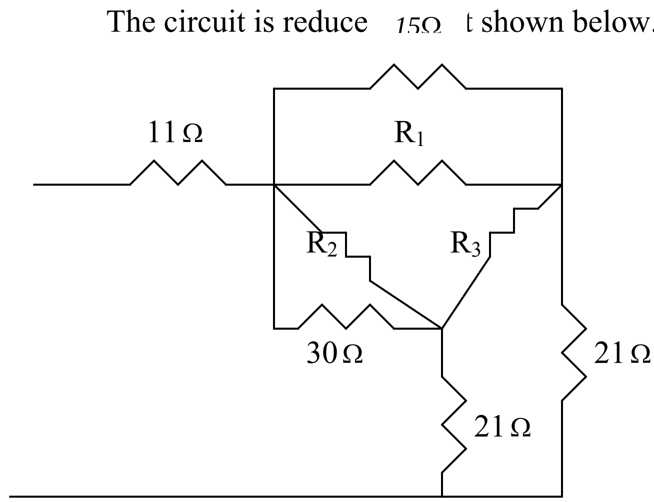
(b) $30//(20+50) = 30//70 = 21\ \Omega$

Convert the T to Y and obtain

$$R_1 = \frac{20x10 + 10x40 + 40x20}{40} = \frac{1400}{40} = 35\Omega$$

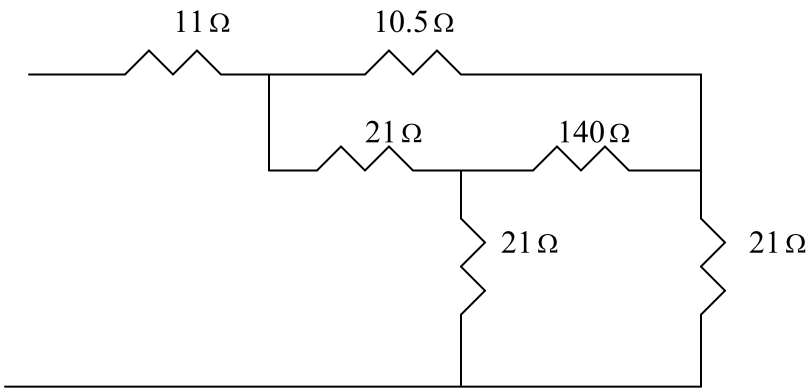
$$R_2 = \frac{1400}{20} = 70\Omega, \quad R_3 = \frac{1400}{10} = 140\Omega$$

The circuit is reduce t shown below.

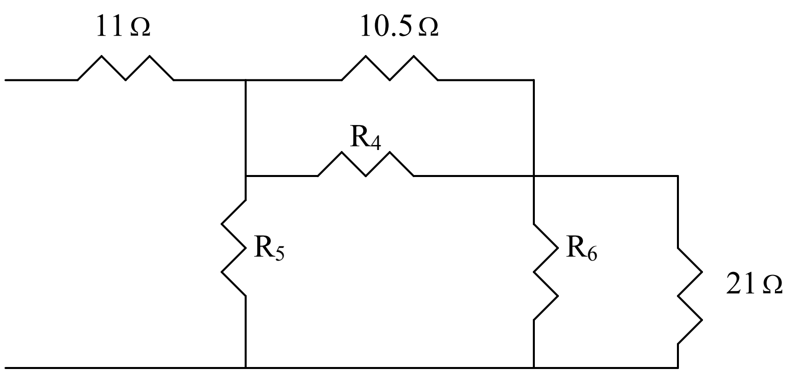


Combining the resistors in parallel

$R_1//15 = 35//15 = 10.5$, $30//R_2 = 30//70 = 21$
leads to the circuit below.



Coverting the T to Y leads to the circuit below.



$$R_4 = \frac{21x140 + 140x21 + 21x21}{21} = \frac{6321}{21} = 301\Omega = R_6$$

$$R_5 = \frac{6321}{140} = 45.15$$

$10.5//301 = 10.15$, $301//21 = 19.63$
$R_5//(10.15 + 19.63) = 45.15//29.78 = 17.94$

$$R_{ab} = 11 + 17.94 = \underline{28.94\Omega}$$

Chapter 2, Problem 45.

Find the equivalent resistance at terminals *a*-*b* of each circuit in Fig. 2.109.

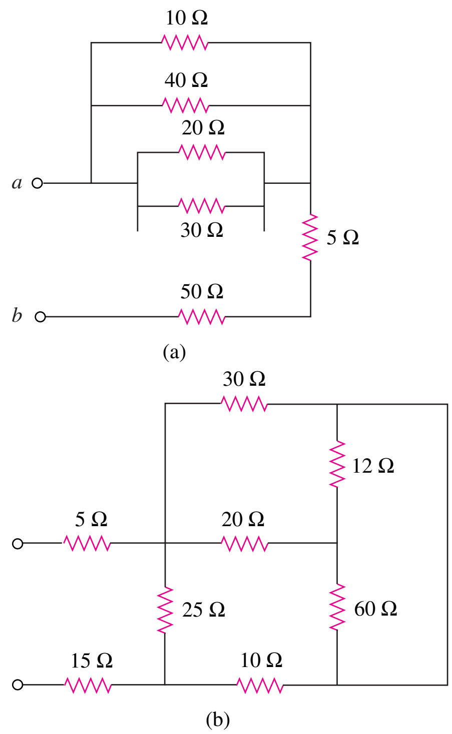


Figure 2.109

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, Problem 46.
Find I in the circuit of Fig. 2.110.

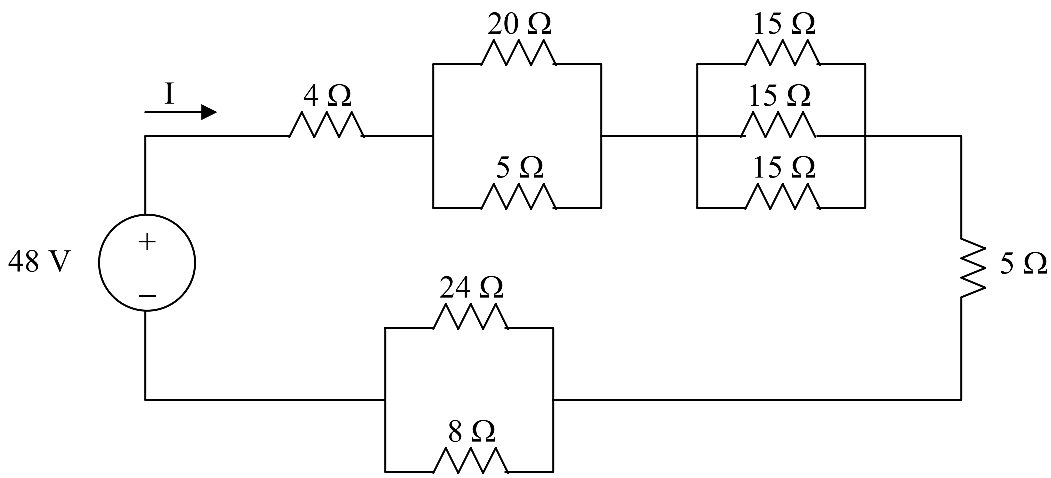


Figure 2.110 For Prob. 2.46.

Chapter 2, Solution 46

$$R_{eq} = 4 + 5 // 20 + \frac{1}{3} x15 + 5 + 24 // 8 = 4 + 4 + 5 + 5 + 6 = 24$$

I = 48/24 = **2 A**

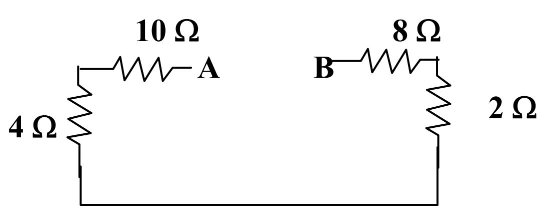
Chapter 2, Problem 47.

Find the equivalent resistance R_{ab} in the circuit of Fig. 2.111.

Chapter 2, Solution 47

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

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



R_{ab} = 10 + 4 + 2 + 8 = **24 Ω**

Chapter 2, Problem 48.

Convert the circuits in Fig. 2.112 from Y to Δ.

Chapter 2, Solution 48

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

$R_a = R_b = R_c = \underline{\mathbf{30\ \Omega}}$

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

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

$R_a = \underline{\mathbf{103.3\ \Omega}}$, $R_b = \underline{\mathbf{155\ \Omega}}$, $R_c = \underline{\mathbf{62\ \Omega}}$

Chapter 2, Problem 49.

Transform the circuits in Fig. 2.113 from Δ to Y.

Chapter 2, Solution 49

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

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

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

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

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

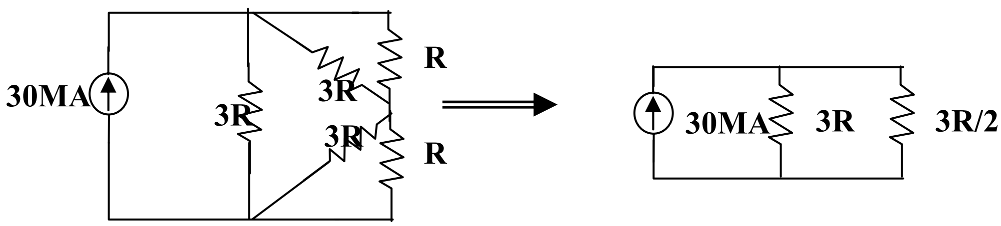
$\mathbf{R_1 = 18\Omega, R_2 = 6\Omega, R_3 = 3\Omega}$

Chapter 2, Problem 50.

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

Chapter 2, Solution 50

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



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

$$3R \| (3RxR)/(4R) = 3/(4R)$$

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

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

R = **<u>889 Ω</u>**

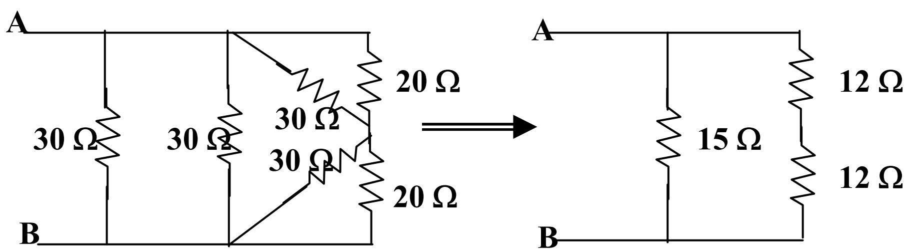
Chapter 2, Problem 51.

Obtain the equivalent resistance at the terminals *a*-*b* for each of the circuits in Fig. 2.115.

Chapter 2, Solution 51

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

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



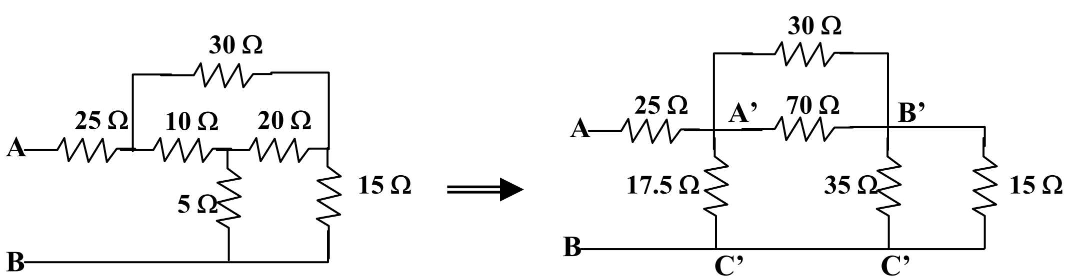
(b) Converting the T-subnetwork into its equivalent Δ network gives

$R_{a'b'}$ = 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 $35/(15) = 35x15/(50) = 10.5$

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

$R_{ab} = \underline{\mathbf{36.25\ \Omega}}$



Chapter 2, Problem 52.

For the circuit shown in Fig. 2.116, find the equivalent resistance. All resistors are 1Ω.

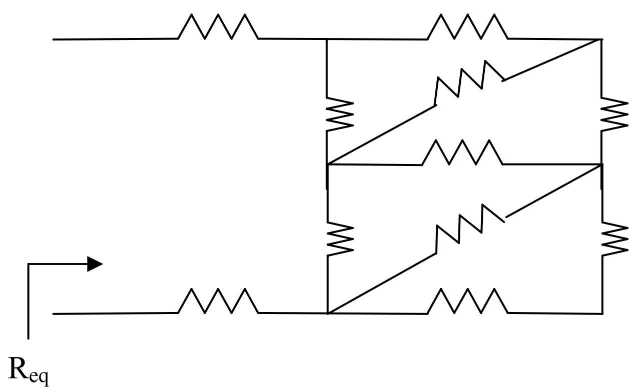
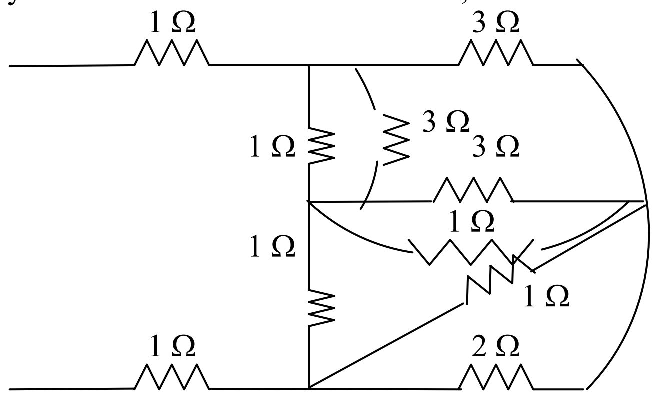


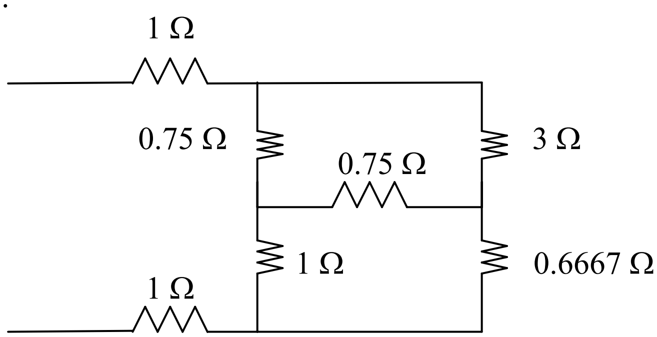
Figure 2.116 For Prob. 2.52.

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.

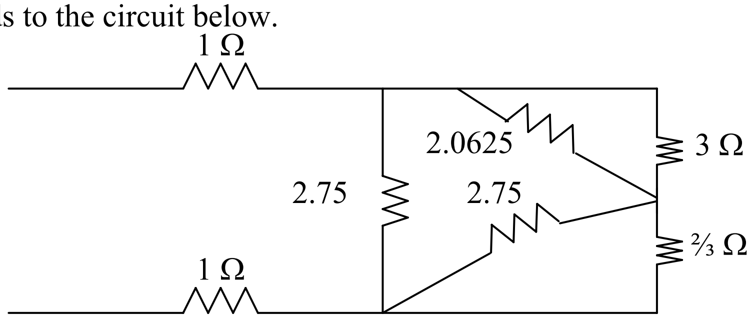


We now convert the wye-subnetwork to the delta-subnetwork.

$$R_a = \frac{0.75x1 + 0.75x1 + 0.75^2}{1} = 2.0625$$

$$R_b = R_c = \frac{2.0625}{0.75} = 2.75$$

This leads to the circuit below.



$$R = 3 // 2.0625 + 2.75 // \frac{2}{3} = \frac{3x2.065}{5.0625} + \frac{2.75x2/3}{2/3 + 2.75} = 1.7607$$

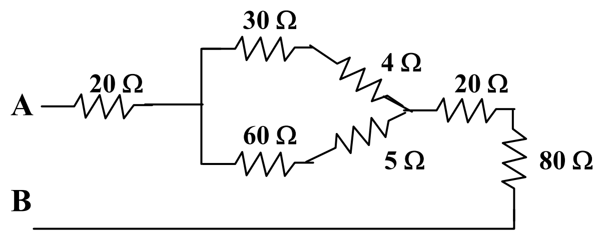
$$R_{eq} = 1 + 1 + 2.75 // 1.7607 = 2 + \frac{2.75x1.7607}{2.75 + 1.7607} = \underline{3.0734\ \Omega}$$

Chapter 2, Problem 53.

Obtain the equivalent resistance R_{ab} in each of the circuits of Fig. 2.117. In (b), all resistors have a value of 30 Ω.

Chapter 2, Solution 53

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



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

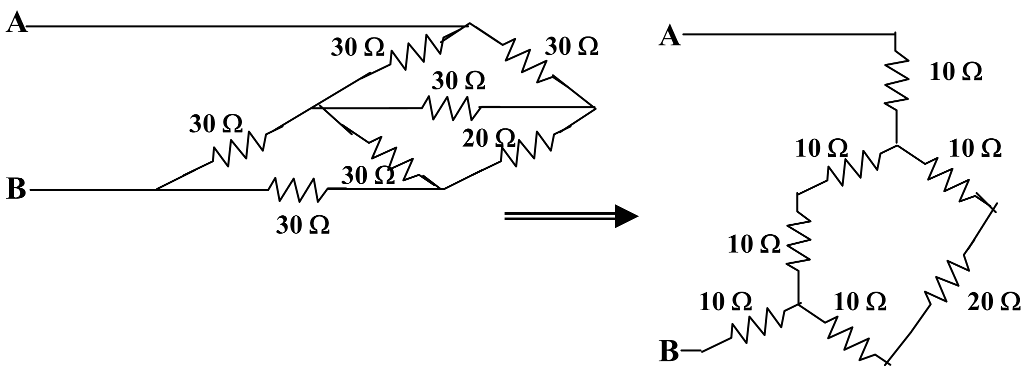
$R_{ab} = 20 + 80 + 20 + (30+4)\|(60+5) = 120 + 34\|65$

$R_{ab} =$ **$\underline{142.32\ \Omega}$**

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

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

We convert the balanced Δ s to Ts as shown below:



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

$\underline{R_{ab} = 33.33\ \Omega}$

Chapter 2, Problem 54.

Consider the circuit in Fig. 2.118. Find the equivalent resistance at terminals: (a) *a-b*, (b) *c-d*.

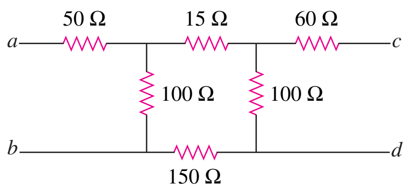


Figure 2.118

Chapter 2, Solution 54

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

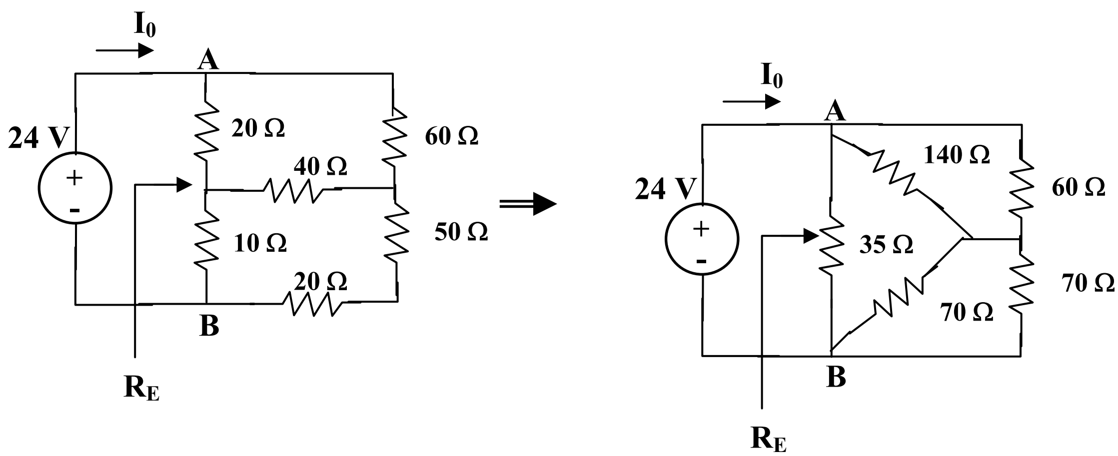
(b) $R_{ab} = 60 + 100 // (150 + 100 + 150) = 60 + 100 // 400 = \underline{140\Omega}$

Chapter 2, Problem 55.

Calculate I_o in the circuit of Fig. 2.119.

Chapter 2, Solution 55

We convert the T to Δ.



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

$R_{ac} = 1400/(10) = 140\Omega$, $R_{bc} = 1400/(20) = 70\Omega$

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

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

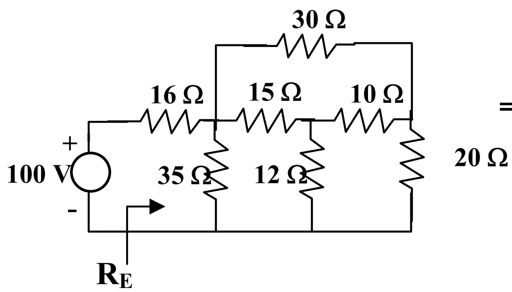
$I_0 = 24/(R_{ab}) =$ **997.4mA**

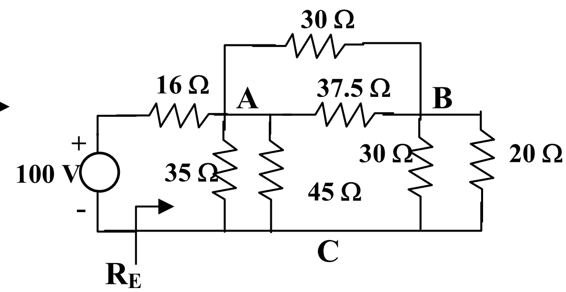
Chapter 2, Problem 56.

Determine V in the circuit of Fig. 1.120.

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,

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

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

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

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

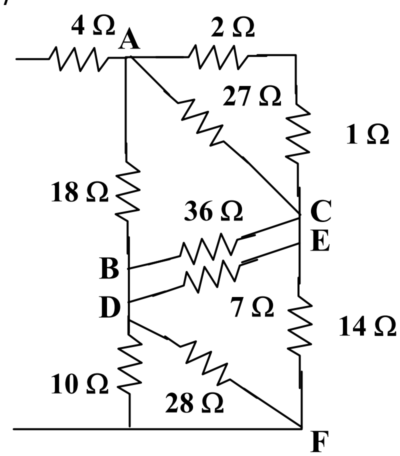
By voltage division,

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

Chapter 2, Problem 57.

Find R_{eq} and I in the circuit of Fig. 2.121.

Chapter 2, Solution 57



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

$R_{ac} = 216/(8) = 27\Omega$, $R_{bc} = 36\ \Omega$

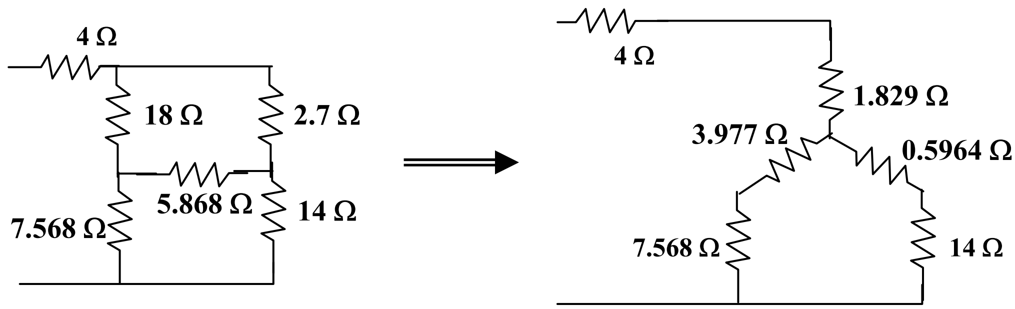
$$R_{de} = \frac{4x2 + 2x8 + 8x4}{8} = \frac{56}{8} 7\ \Omega$$

$R_{ef} = 56/(4) = 14\Omega$, $R_{df} = 56/(2) = 28\ \Omega$

Combining resistors in parallel,

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

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



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

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

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

$$R_{eq} = 4+1.829+(3.977+7.368)\|(0.5964+14)$$

$$= 5.829+11.346\|14.5964 = \underline{\mathbf{12.21\ \Omega}}$$

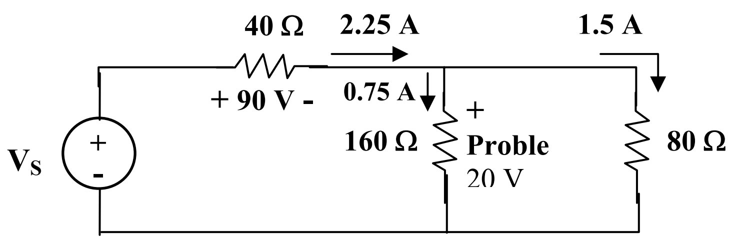
$i = 20/(R_{eq}) =$ **<u>1.64 A</u>**

Chapter 2, Problem 58.

The lightbulb in Fig. 2.122 is rated 120 V, 0.75 A. Calculate V_s to make the lightbulb operate at the rated conditions.

Chapter 2, Solution 58

The resistor of the bulb is $120/(0.75) = 160\Omega$



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

$$40(0.75 + 1.5) = 2.25 \times 40 = 90$$

Thus

$$v_s = 90 + 120 = \underline{\mathbf{210\ V}}$$

Chapter 2, Problem 59.

Three lightbulbs are connected in series to a 100-V battery as shown in Fig. 2.123. Find the current *I* through the bulbs.

Chapter 2, Solution 59

TOTAL POWER P = 30 + 40 + 50 + 120 W = VI

OR I = P/(V) = 120/(100) = **<u>1.2 A</u>**

Chapter 2, Problem 60.
If the three bulbs of Prob. 2.59 are connected in parallel to the 100-V battery, calculate the current through each bulb.

Chapter 2, Solution 60

$p = iv \qquad i = p/(v)$

$i_{30W} = 30/(100) = \underline{\mathbf{0.3\ A}}$

$i_{40W} = 40/(100) = \underline{\mathbf{0.4\ A}}$

$i_{50W} = 50/(100) = \underline{\mathbf{0.5\ A}}$

Chapter 2, Problem 61.
As a design engineer, you are asked to design a lighting system consisting of a 70-W power supply and two lightbulbs as shown in Fig. 2.124. You must select the two bulbs from the following three available bulbs.

$R_1 = 80\Omega$, cost = \$0.60 (standard size)
$R_2 = 90\Omega$, cost = \$0.90 (standard size)
$R_3 = 100\ \Omega$, cost = \$0.75 (nonstandard size)
The system should be designed for minimum cost such that $I = 1.2$ A ± 5 percent.

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:

$\underline{\mathbf{R_1 \text{ and } R_3}}$

Chapter 2, Problem 62.

A three-wire system supplies two loads *A* and *B* as shown in Fig. 2.125. Load *A* consists of a motor drawing a current of 8 A, while load *B* is a PC drawing 2 A. Assuming 10 h/day of use for 365 days and 6 cents/kWh, calculate the annual energy cost of the system.

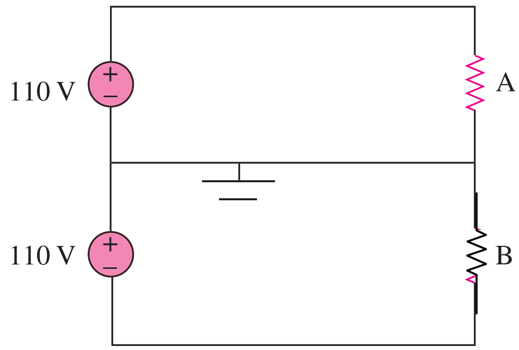


Figure 2.125

Chapter 2, Solution 62

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

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

Chapter 2, Problem 63.

If an ammeter with an internal resistance of 100 Ω and a current capacity of 2 mA is to measure 5 A, determine the value of the resistance needed. Calculate the power dissipated in the shunt resistor.

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

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

Chapter 2, Problem 64.

The potentiometer (adjustable resistor) R_x in Fig. 2.126 is to be designed to adjust current I_x from 1 A to 10 A. Calculate the values of R and R_x to achieve this.

Chapter 2, Solution 64

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

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

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

Thus, $R = \underline{\mathbf{11\ \Omega}}$, $\quad R_x = \underline{\mathbf{99\ \Omega}}$

Chapter 2, Problem 65.

A d'Arsonval meter with an internal resistance of 1 kΩ requires 10 mA to produce full-scale deflection. Calculate the value of a series resistance needed to measure 50 V of full scale.

Chapter 2, Solution 65

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

Chapter 2, Problem 66.

A 20-kΩ/V voltmeter reads 10 V full scale,

(a) What series resistance is required to make the meter read 50 V full scale?
(b) What power will the series resistor dissipate when the meter reads full scale?

Chapter 2, Solution 66

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

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

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

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

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

Chapter 2, Problem 67.

(c) Obtain the voltage v_o in the circuit of Fig. 2.127.
(d) Determine the voltage v'_o measured when a voltmeter with 6-kΩ internal resistance is connected as shown in Fig. 2.127.
(e) The finite resistance of the meter introduces an error into the measurement. Calculate the percent error as

$$\left|\frac{v_o - v'_o}{v_o}\right| \times 100\% .$$

(f) Find the percent error if the internal resistance were 36 kΩ.

Chapter 2, Solution 67

(c) By current division,

$i_0 = 5/(5 + 5)\ (2\ \text{mA}) = 1\ \text{mA}$
$V_0 = (4\ \text{k}\Omega)\ i_0 = 4 \text{ x } 10^3 \text{ x } 10^{-3} = \underline{\mathbf{4\ V}}$

(d) $4\text{k}\| 6\text{k} = 2.4\text{k}\Omega$. By current division,

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

$$v_0' = (2.4\ \text{k}\Omega)(1.19\ \text{mA}) = \underline{\mathbf{2.857\ V}}$$

(e) $\% \text{ error} = \left|\frac{v_0 - v_0'}{v_0}\right| \text{ x } 100\% = \frac{1.143}{4}\text{x}100 = \underline{\mathbf{28.57\%}}$

(f) $4\text{k}\| 36\ \text{k}\Omega = 3.6\ \text{k}\Omega$. By current division,

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

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

$$\% \text{ error} = \left|\frac{v - v_0'}{v_0}\right|\text{x}100\% = \frac{0.25\text{x}100}{4} = \underline{\mathbf{6.25\%}}$$

Chapter 2, Problem 68.

(f) Find the current i in the circuit of Fig. 2.128(a).
(g) An ammeter with an internal resistance of 1 Ω is inserted in the network to measure i' as shown in Fig. 2.128 (b). What is i''?
(h) Calculate the percent error introduced by the meter as

$$\left|\frac{i - i'}{i}\right| \times 100\%$$

Chapter 2, Solution 68

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

$$\text{i} = \frac{4}{16+24} = \underline{\mathbf{0.1\ A}}$$

(G) $$\text{i}' = \frac{4}{16+1+24} = \underline{\mathbf{0.09756\ A}}$$

(H) $$\%\ \text{error} = \frac{0.1 - 0.09756}{0.1}\text{x}100\% = \underline{\mathbf{2.44\%}}$$

Chapter 2, Problem 69.

A voltmeter is used to measure V_o in the circuit in Fig. 2.122. The voltmeter model consists of an ideal voltmeter in parallel with a 100-kΩ resistor. Let V_s = 40 V, R_s = 10 kΩ, and R_1 = 20 kΩ. Calculate V_o with and without the voltmeter when

(a) R_2 = 1 kΩ (b) R_2 = 10 kΩ

(c) R_2 = 100 kΩ

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

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

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

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

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

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

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

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

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

Chapter 2, Problem 70.

(a) Consider the Wheatstone Bridge shown in Fig. 2.130. Calculate v_a , v_b , and
(b) Rework part (a) if the ground is placed at *a* instead of *o*.

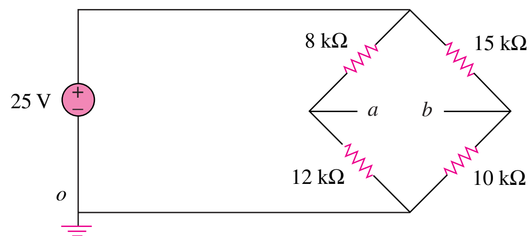


Figure 2.130

Chapter 2, Solution 70

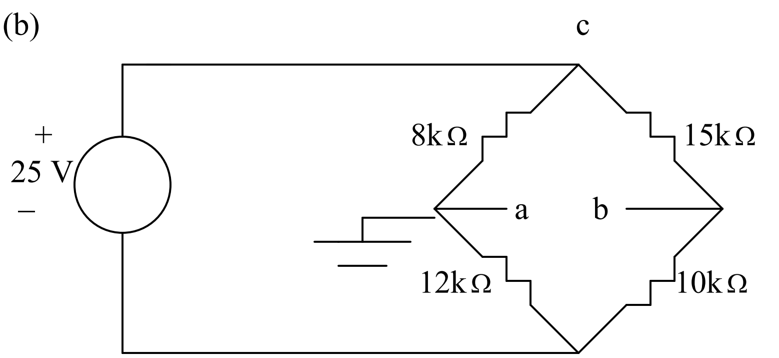
(a) Using voltage division,

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

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

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

(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, Problem 71.

Figure 2.131 represents a model of a solar photovoltaic panel. Given that v_s = 30 **V**, R_1 = 20 Ω, I_L = 1 **A**, find R_L.

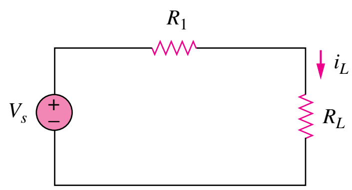
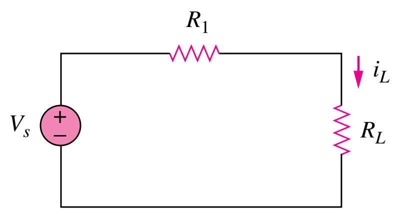


Figure 2.131

Chapter 2, Solution 71



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

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

Chapter 2, Problem 72.
Find V_o in the two-way power divider circuit in Fig. 2.132.

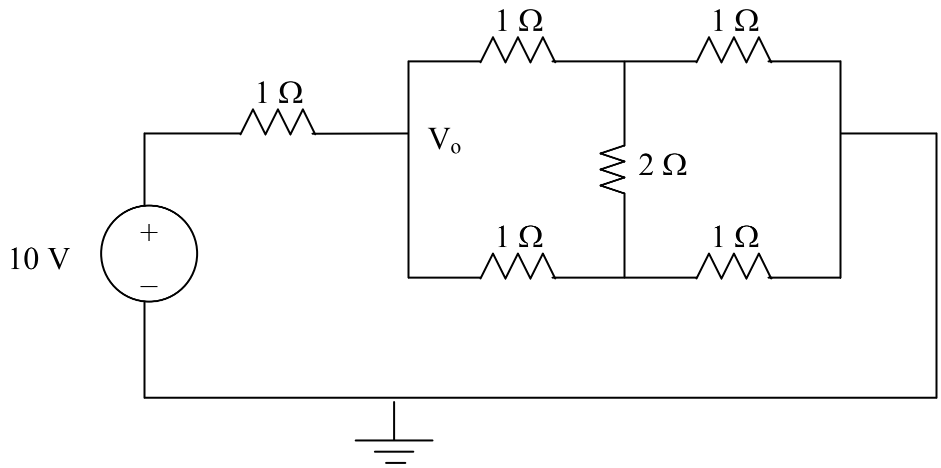
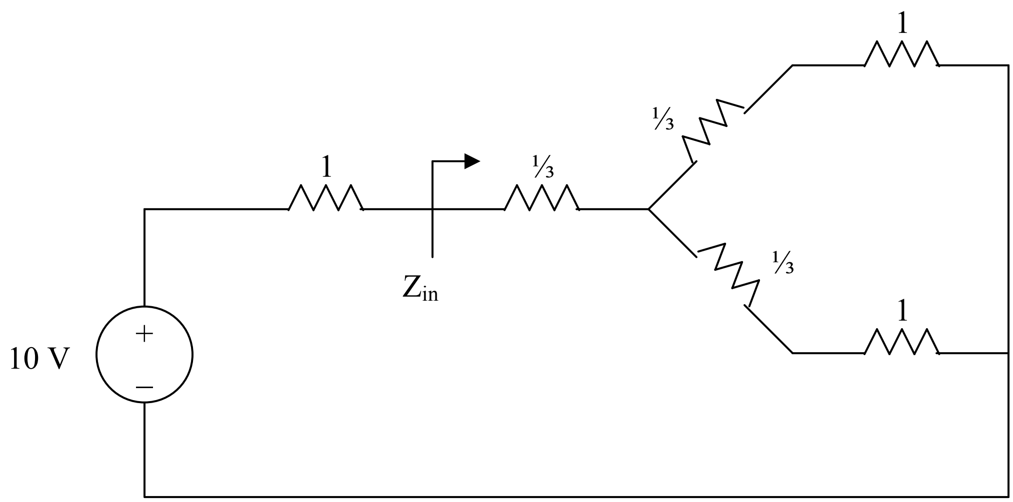


Figure 2.132 For Prob. 2.72.

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, Problem 73.

An ammeter model consists of an ideal ammeter in series with a 20-Ω resistor. It is connected with a current source and an unknown resistor R_x as shown in Fig. 2.133. The ammeter reading is noted. When a potentiometer R is added and adjusted until the ammeter reading drops to one half its previous reading, then $R = 65\ \Omega$. What is the value of R_x?

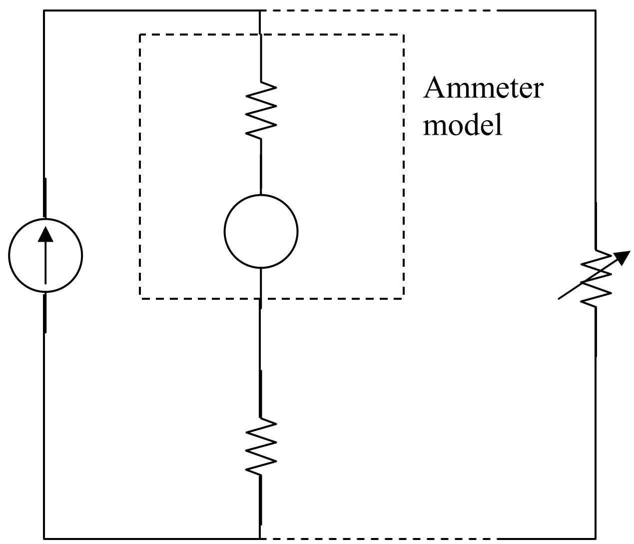


Figure 2.133

Chapter 2, Solution 73

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

$R = 20 + R_x$

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

Chapter 2, Problem 74.

The circuit in Fig. 2.134 is to control the speed of a motor such that the motor draws currents 5 A, 3 A, and 1 A when the switch is at high, medium, and low positions, respectively. The motor can be modeled as a load resistance of 20 mΩ. Determine the series dropping resistances R_1, R_2, and R_3.

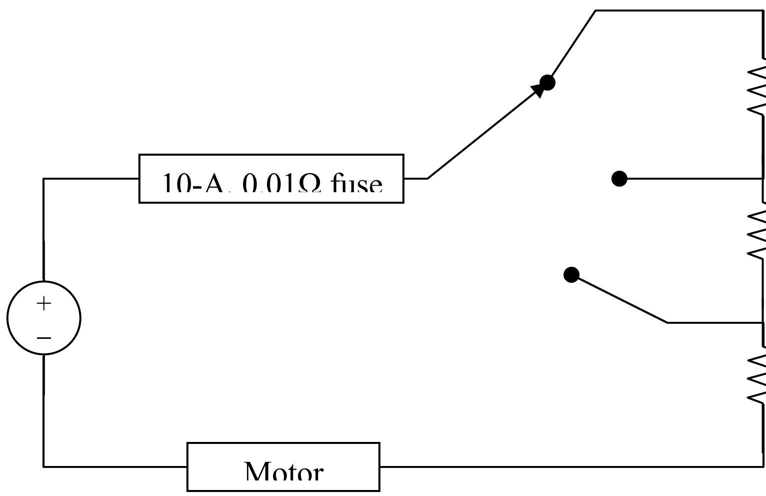


Figure 134

Chapter 2, Solution 74

With the switch in high position,

$$6 = (0.01 + R_3 + 0.02) \times 5 \longrightarrow R_3 = \underline{\mathbf{1.17\ \Omega}}$$

At the medium position,

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

$$\text{or } R_2 = 1.97 - 1.17 = \underline{\mathbf{0.8\ \Omega}}$$

At the low position,

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

Chapter 2, Problem 75.

Find Z_{ab} in the four-way power divider circuit in Fig. 2.135. Assume each element is 1Ω.

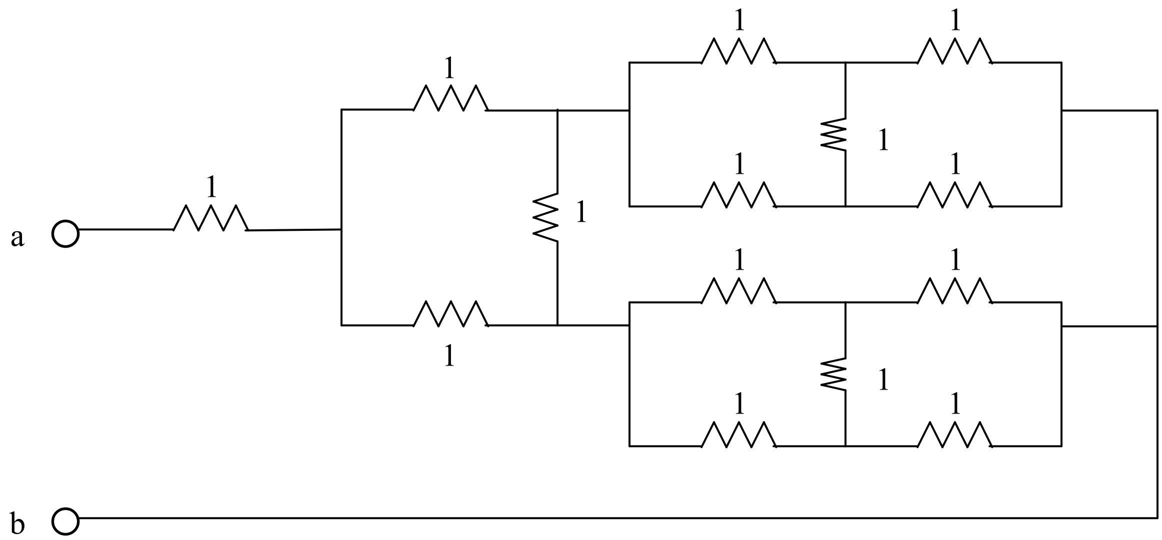
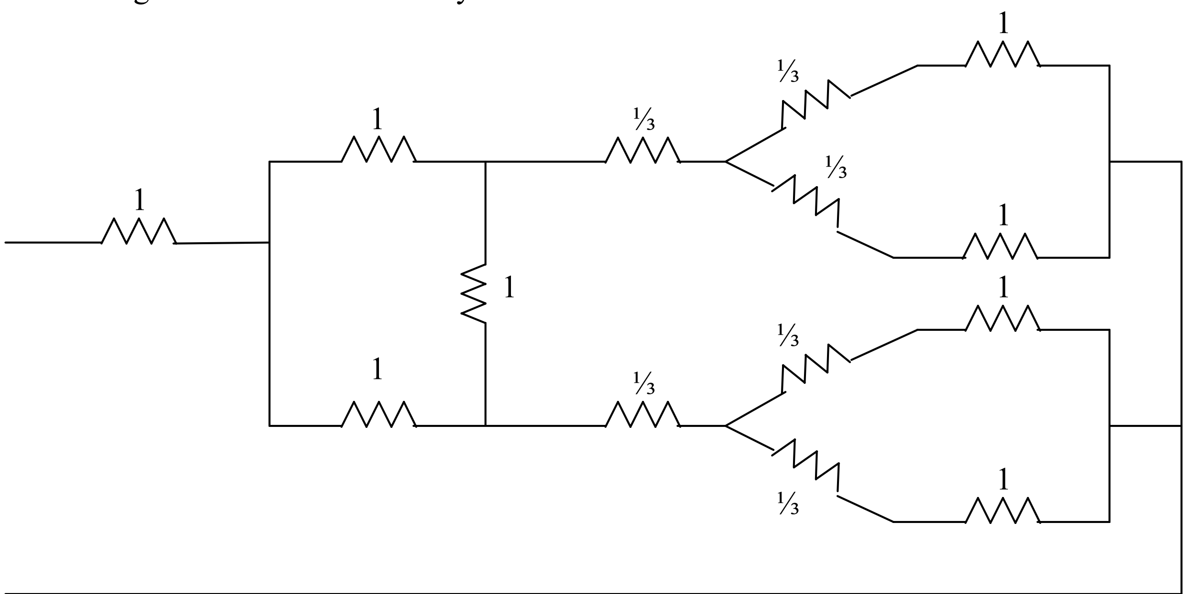


Figure 2.135 For Prob. 2.75.

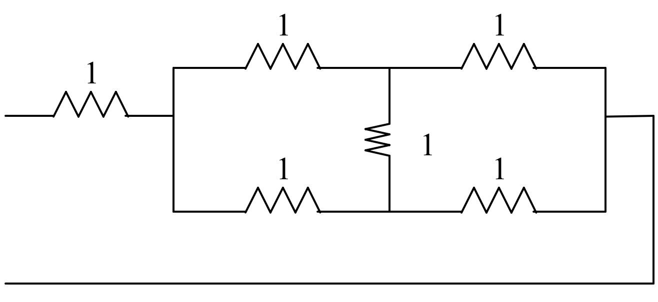
Chapter 2, Solution 75

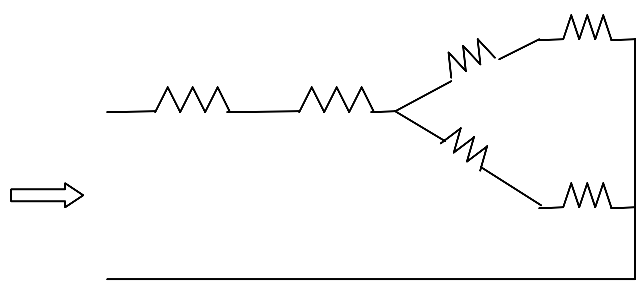
Converting delta-subnetworks to wye-subnetworks leads to the circuit below.



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

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, Problem 76.

Repeat Prob. 2.75 for the eight-way divider shown in Fig. 2.136.

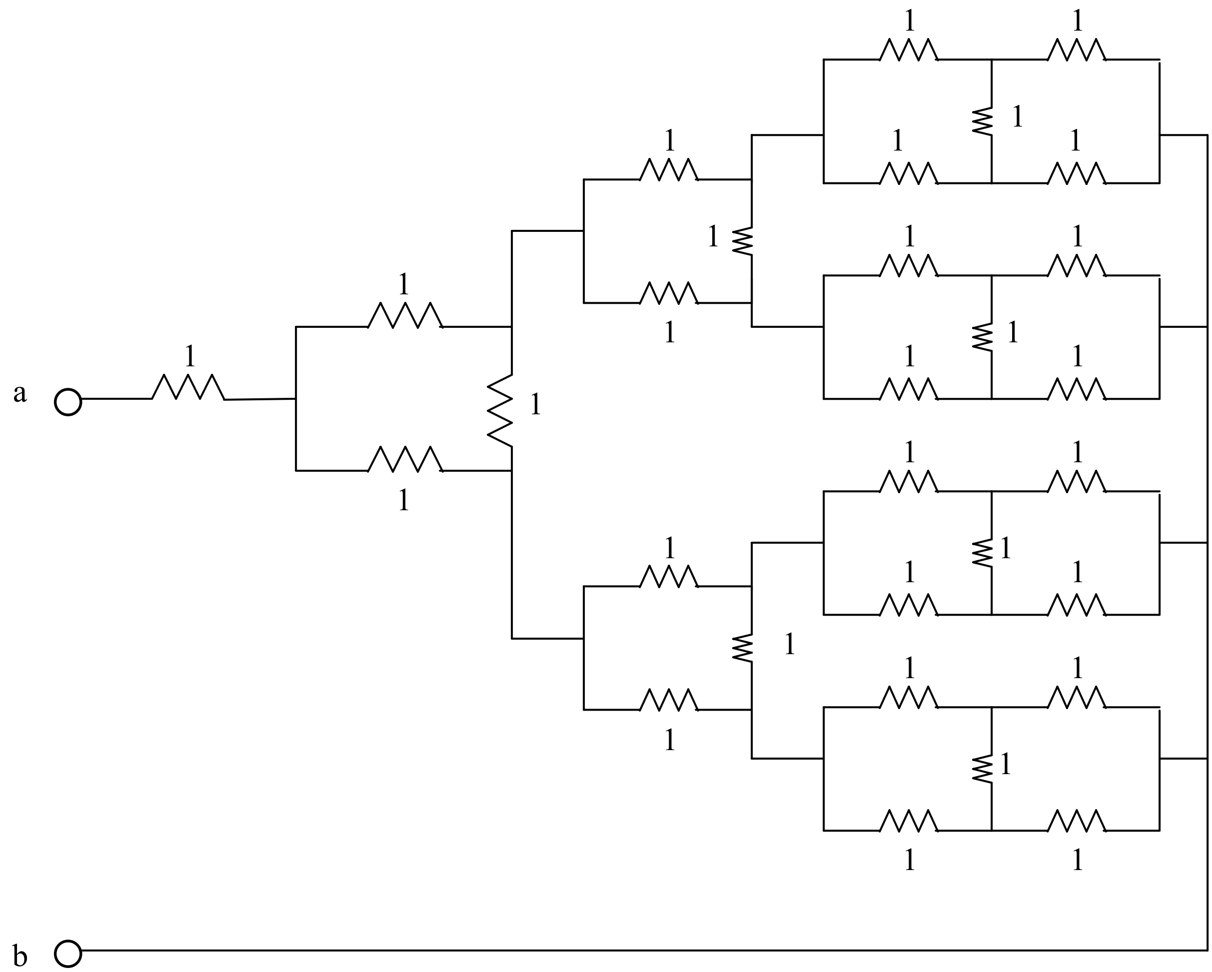


Figure 2.136 For Prob. 2.76.

Chapter 2, Solution 76

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

Chapter 2, Problem 77.

Suppose your circuit laboratory has the following standard commercially available resistors in large quantities:

1.8 Ω   20 Ω   300 Ω   24 kΩ   56 kΩ

Using series and parallel combinations and a minimum number of available resistors, how would you obtain the following resistances for an electronic circuit design?

(a) 5 Ω   (b) 311.8 Ω

(c) 40 kΩ   (d) 52.32 kΩ

Chapter 2, Solution 77

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

i.e., **<u>four 20 Ω resistors in parallel</u>.**

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

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

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

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

(d)
$$42.32\text{k}\Omega = 42l + 320$$
$$= 24\text{k} + 28\text{k} = 320$$
$$= 24\text{k} = 56\text{k}\|56\text{k} + 300 + 20$$

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

Chapter 2, Problem 78.

In the circuit in Fig. 2.137, the wiper divides the potentiometer resistance between αR and $(1 - \alpha)R$, $0 \leq \alpha \leq 1$. Find v_o / v_s.

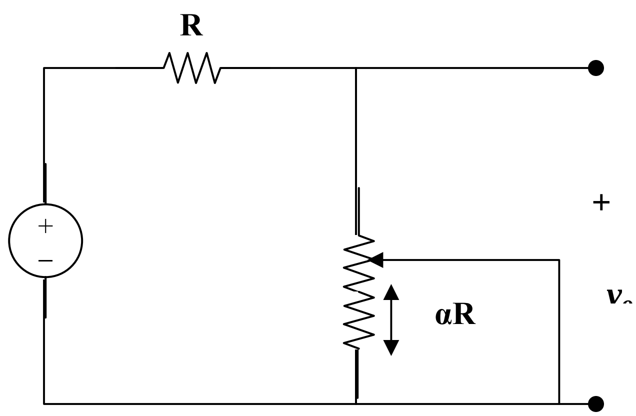
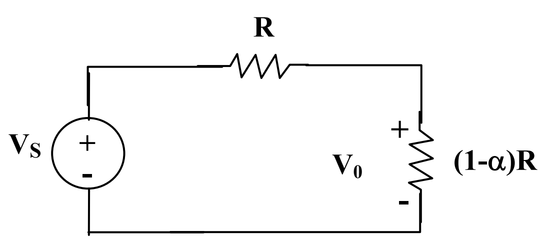


Figure 137

Chapter 2, Solution 78

The equivalent circuit is shown below:



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

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

Chapter 2, Problem 79.

An electric pencil sharpener rated 240 mW, 6 V is connected to a 9-V battery as shown in Fig. 2.138. Calculate the value of the series-dropping resistor R_x needed to power the sharpener.

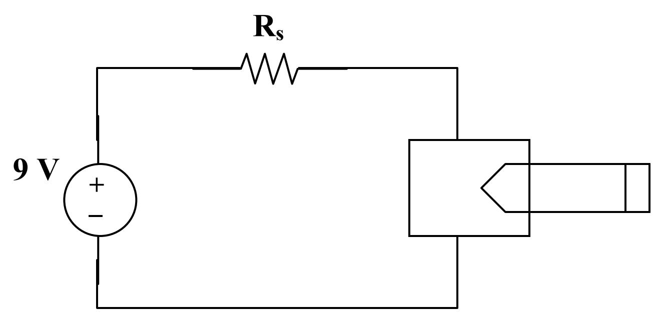


Figure 138

Chapter 2, Solution 79

Since $p = v^2/R$, the resistance of the sharpener is

$R = v^2/(p) = 6^2/(240 \text{ x } 10^{-3}) = 150\Omega$
$I = p/(v) = 240 \text{ mW}/(6V) = 40 \text{ mA}$

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

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

Chapter 2, Problem 80.

A loudspeaker is connected to an amplifier as shown in Fig. 2.139. If a 10-Ω loudspeaker draws the maximum power of 12 W from the amplifier, determine the maximum power a 4-Ω loudspeaker will draw.

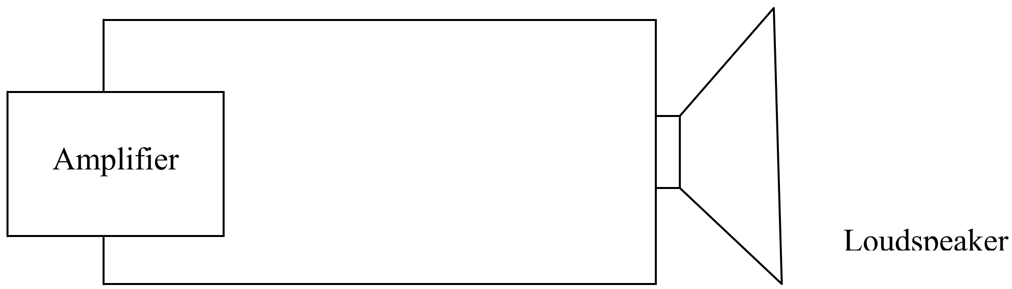
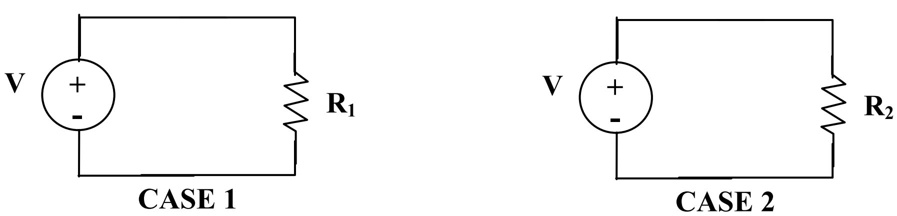


Figure 139

Chapter 2, Solution 80

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



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

Chapter 2, Problem 81.

In a certain application, the circuit in Figure 2.140 must be designed to meet these two criteria:
(a) $V_o / V_s = 0.05$ (b) $R_{eq} = 40$ kΩ

If the load resistor 5 kΩ is fixed, find R_1 and R_2 to meet the criteria.

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

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

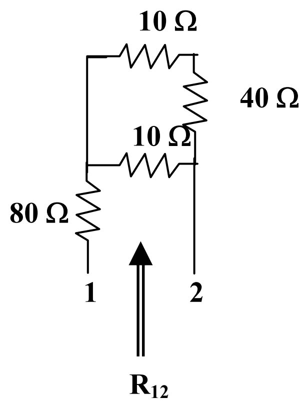
Thus **$R_1 = 38$ kΩ, $R_2 = 3.333$ kΩ**

Chapter 2, Problem 82.
The pin diagram of a resistance array is shown in Fig. 2.141. Find the equivalent resistance between the following:

(a) 1 and 2 (b) 1 and 3 (c) 1 and 4

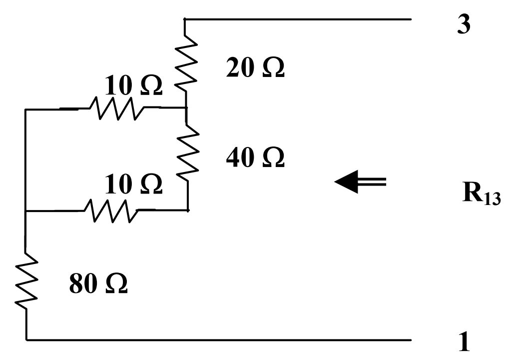
Chapter 2, Solution 82

(a)



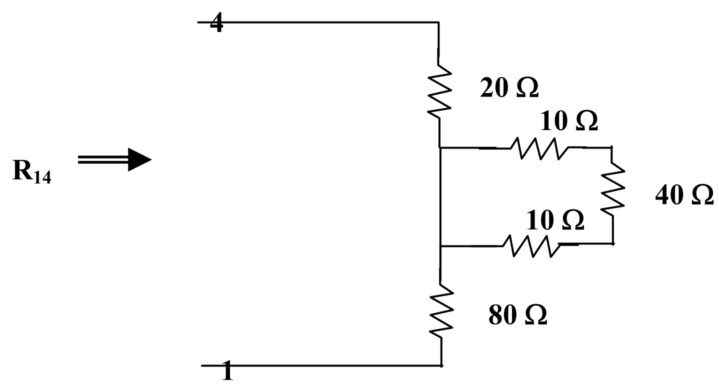
$R_{12} = 80 + 10\|(10+40) = 80 + \frac{50}{6} =$ $\underline{\mathbf{88.33\ \Omega}}$

(b)



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

(c)



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

Chapter 2, Problem 83.

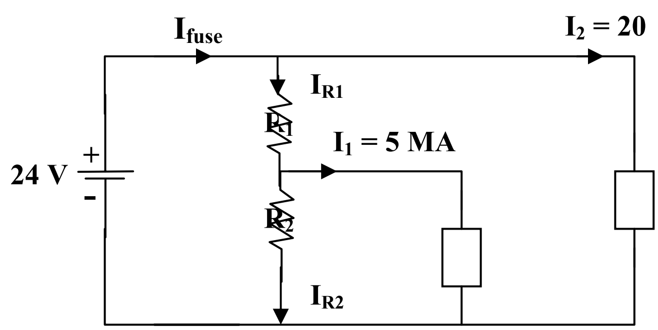
Two delicate devices are rated as shown in Fig. 2.142. Find the values of the resistors R_1 and R_2 needed to power the devices using a 24-V battery.

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.

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

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



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.

$9 = (24/(R_1 + 1800))1800$ or $R_1 = (24/9)1800 - 1800 = \underline{\mathbf{3{,}000\Omega}}$

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.