Chapter 2, Solution 1

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

Chapter 2, Solution 2

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

Chapter 2, Solution 3

R = v/i = 120/(2.5x10^{-3}) = **48k ohms**

Chapter 2, Solution 4

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

Chapter 2, Solution 5

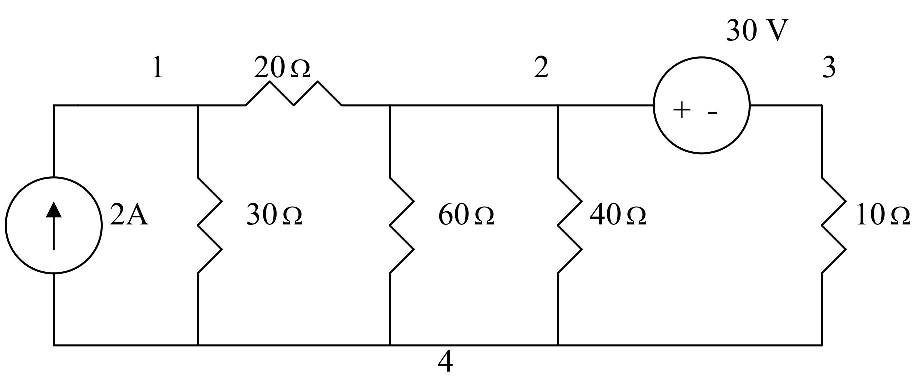
n = 9; l = 7; **b** = n + l – 1 = **15**

Chapter 2, Solution 6

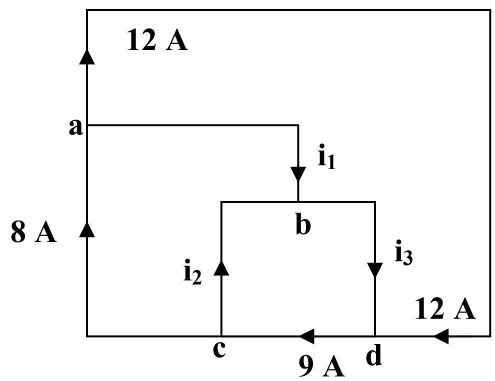
n = 12; l = 8; **b** = n + l –1 = **19**

Chapter 2, Solution 7

7 elements or 7 branches and 4 nodes, as indicated.



Chapter 2, Solution 8



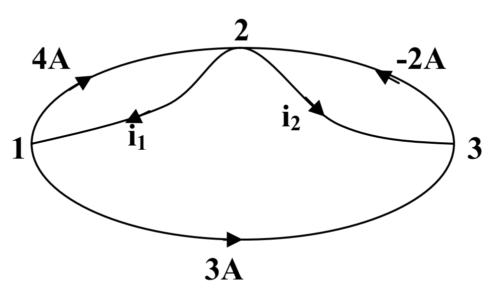
At node a, $8 = 12 + i_1$ ⟶ $\underline{i_1 = -4A}$
At node c, $9 = 8 + i_2$ ⟶ $\underline{i_2 = 1A}$
At node d, $9 = 12 + i_3$ ⟶ $\underline{i_3 = -3A}$

Chapter 2, Solution 9

Applying KCL,

$i_1 + 1 = 10 + 2$ ⟶ $i_1 = \underline{11A}$
$1 + i_2 = 2 + 3$ ⟶ $i_2 = \underline{4A}$
$i_2 = i_3 + 3$ $i_3 = \underline{1A}$

Chapter 2, Solution 10



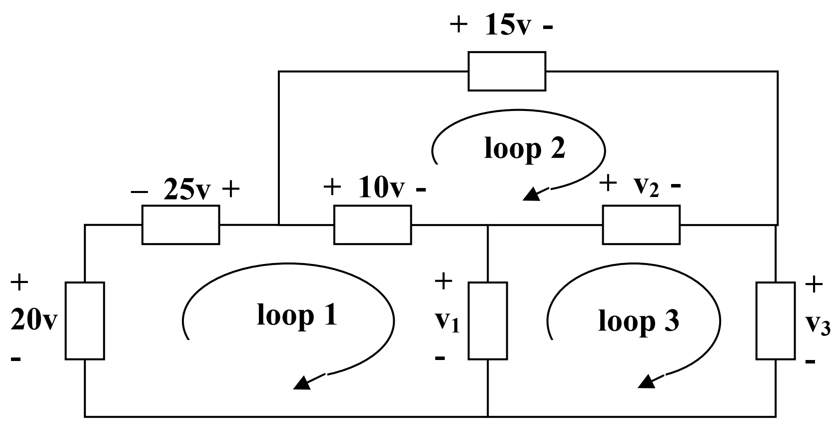
At node 1, $4 + 3 = i_1$ ⟶ $i_1 = \underline{7A}$
At node 3, $3 + i_2 = -2$ ⟶ $i_2 = \underline{-5A}$

Chapter 2, Solution 11

Applying KVL to each loop gives

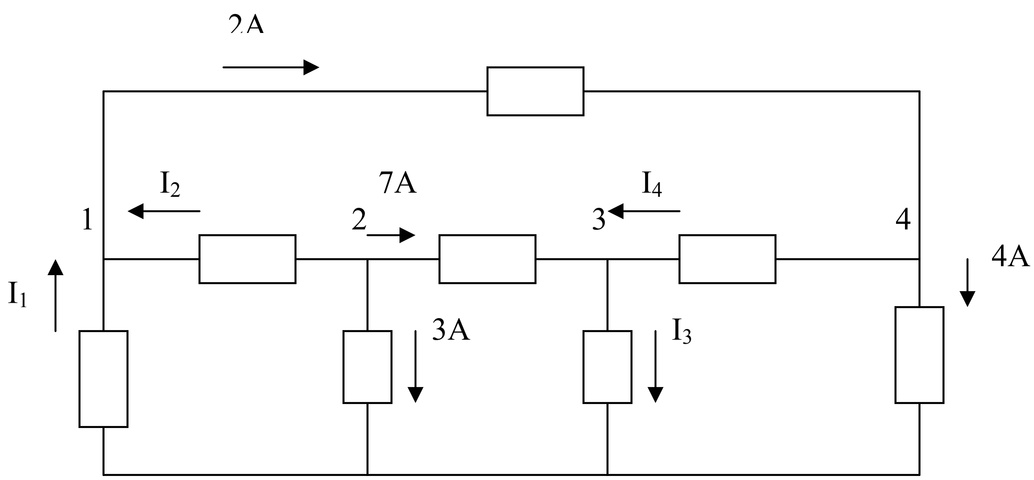
$-8 + v_1 + 12 = 0 \longrightarrow$ **$v_1 = 4v$**
$-12 - v_2 + 6 = 0 \longrightarrow$ **$v_2 = -6v$**
$10 - 6 - v_3 = 0 \longrightarrow$ **$v_3 = 4v$**
$-v_4 + 8 - 10 = 0$ **$v_4 = -2v$**

Chapter 2, Solution 12



For loop 1, $-20 -25 +10 + v_1 = 0 \longrightarrow$ **$v_1 = 35v$**
For loop 2, $-10 +15 -v_2 = 0 \longrightarrow$ **$v_2 = 5v$**
For loop 3, **$-v_1 +v_2 +v_3 = 0$** $\longrightarrow$ $v_3 = 30v$

Chapter 2, Solution 13



At node 2,

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

At node 1,

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

At node 4,

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

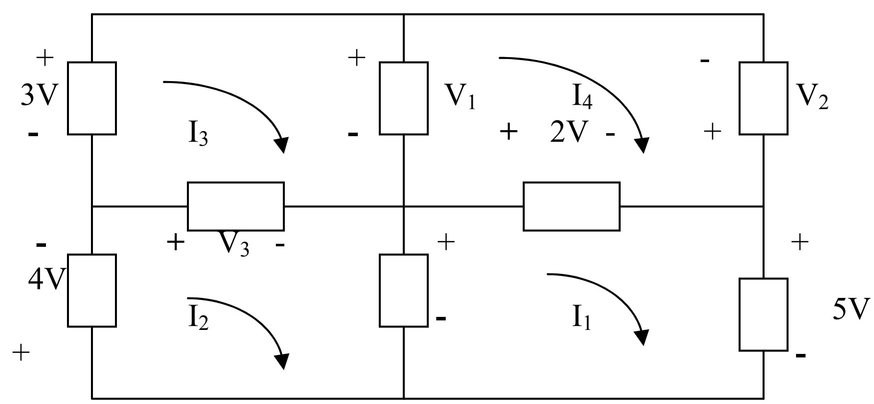
At node 3,

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

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,

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

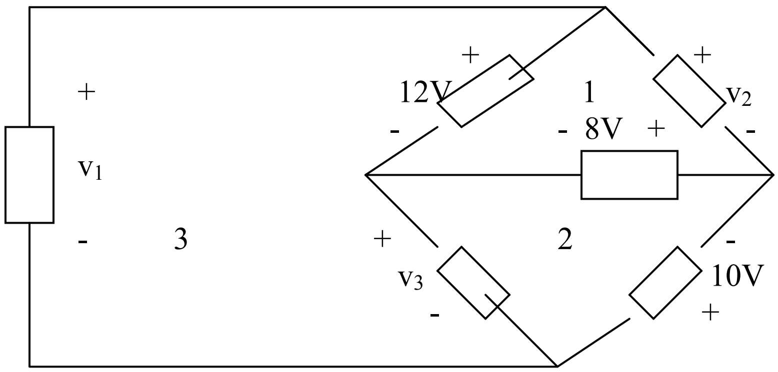
For mesh 4,

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

Thus,

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

Chapter 2, Solution 15



For loop 1,

$$8 - 12 + v_2 = 0 \longrightarrow v_2 = 4V$$

For loop 2,

$$-v_3 - 8 - 10 = 0 \longrightarrow v_3 = -18V$$

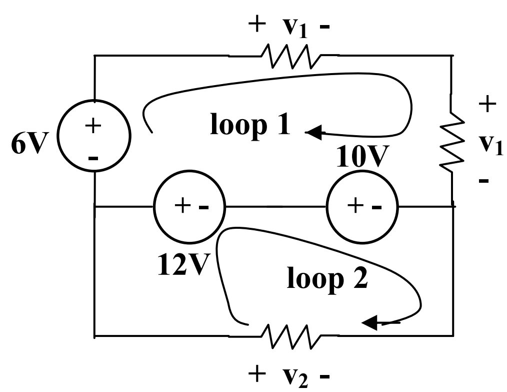
For loop 3,

$$-v_1 + 12 + v_3 = 0 \longrightarrow v_1 = -6V$$

Thus,

$$\underline{v_1 = -6V, \quad v_2 = 4V, \quad v_3 = -18V}$$

Chapter 2, Solution 16



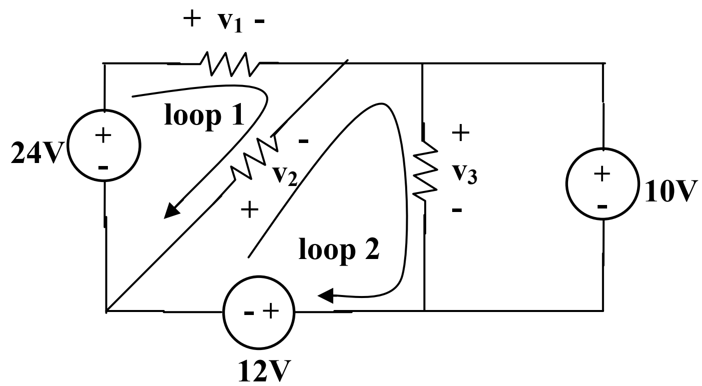
Applying KVL around loop 1,

$$-6 + v_1 + v_1 - 10 - 12 = 0 \longrightarrow v_1 = \underline{\mathbf{14V}}$$

Applying KVL around loop 2,

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

Chapter 2, Solution 17



It is evident that $v_3 = 10V$

Applying KVL to loop 2,

$$v_2 + v_3 + 12 = 0 \longrightarrow v_2 = -22V$$

Applying KVL to loop 1,

$$-24 + v_1 - v_2 = 0 \longrightarrow v_1 = 2V$$

Thus,

$v_1 =$ **2V**, $v_2 =$ **-22V**, $v_3 =$ **10V**

Chapter 2, Solution 18

Applying KVL,

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

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

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

Chapter 2, Solution 19

Applying KVL around the loop, we obtain

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

Power dissipated by the resistor:

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

Power supplied by the sources:

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

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

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

Chapter 2, Solution 20

Applying KVL around the loop,

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

Chapter 2, Solution 21 $\longrightarrow$

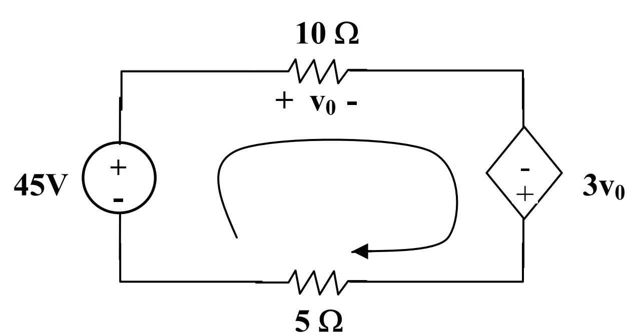
Apply KVL to obtain

$-45 + 10i - 3V_0 + 5i = 0$

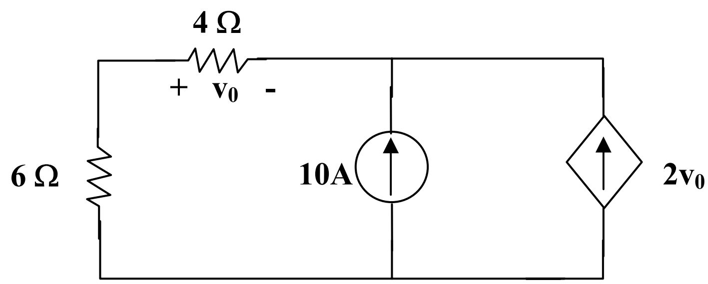
But $v_0 = 10i$,

$-45 + 15i - 30i = 0 \longrightarrow i = -3A$

$P_3 = i^2R = 9 \times 5 =$ **$\underline{45W}$**



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

$$i = 2V_0 = -8.888A$$

and the voltage across it is

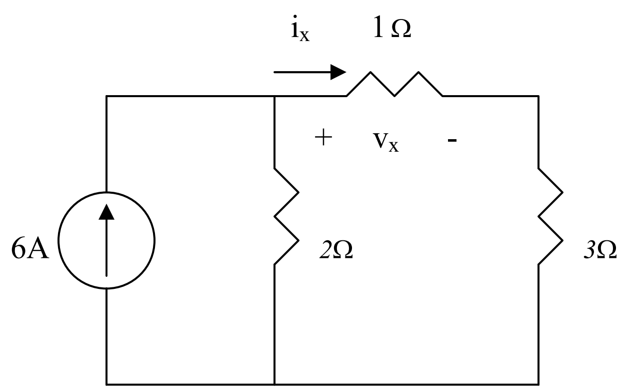
$$v = (6 + 4)\ i_0 = 10\frac{v_0}{4} = -11.111$$

Hence,

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

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,

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

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, Solution 24

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

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

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

(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, Solution 25

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

Using current division,

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

V_{20} = 20 x 0.1 kV = **<u>2 kV</u>**

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

Chapter 2, Solution 26

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

Using current division,

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

$V_{20} = 20 \times 0.1$ kV = **2 kV**

$p_{20} = I_{20} V_{20} =$ **0.2 kW**

Chapter 2, Solution 27

Using current division,

$$i_1 = \frac{4}{4+6}(20) = \underline{\mathbf{8\ A}}$$

$$i_2 = \frac{6}{4+6}(20) = \underline{\mathbf{12\ A}}$$

Chapter 2, Solution 28

We first combine the two resistors in parallel

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

We now apply voltage division,

$$v_1 = \frac{14}{14+6}(40) = \underline{\mathbf{20\ V}}$$

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

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

Chapter 2, Solution 29

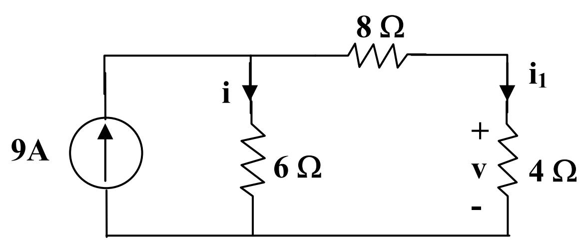
The series combination of 6 Ω and 3 Ω resistors is shorted. Hence

$i_2 = 0 = v_2$

$v_1 = 12,\ i_1 = \frac{12}{4} = 3\ \text{A}$

Hence $v_1 = \underline{\mathbf{12\ V}},\ i_1 = \underline{\mathbf{3\ A}},\ i_2 = \underline{\mathbf{0}} = v_2$

Chapter 2, Solution 30



By current division, $i = \frac{12}{6+12}(9) = \underline{\mathbf{6\ A}}$

$i_1 = 9 - 6 = 3\text{A},\ v = 4i_1 = 4 \times 3 = \underline{\mathbf{12\ V}}$

$p_6 = 1^2R = 36 \times 6 = \underline{\mathbf{216\ W}}$

Chapter 2, Solution 31

The 5 Ω resistor is in series with the combination of $10 \| (4+6) = 5\Omega$.

Hence by the voltage division principle,

$v = \frac{5}{5+5}(20\text{V}) = \underline{\mathbf{10\ V}}$

by ohm's law,

$i = \frac{v}{4+6} = \frac{10}{4+6} = \underline{\mathbf{1\ A}}$

$p_p = i^2R = (1)^2(4) = \underline{\mathbf{4\ W}}$

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,

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

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

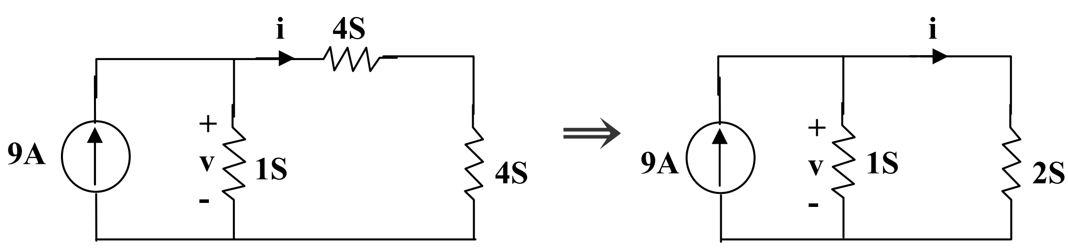
$$i_2 = \frac{30}{50}(8) = \underline{\mathbf{4.8\ A}}$$

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

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

Chapter 2, Solution 33

Combining the conductance leads to the equivalent circuit below



$$6S\|3S = \frac{6x3}{9} = 25 \text{ and } 25 + 25 = 4\text{ S}$$

Using current division,

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

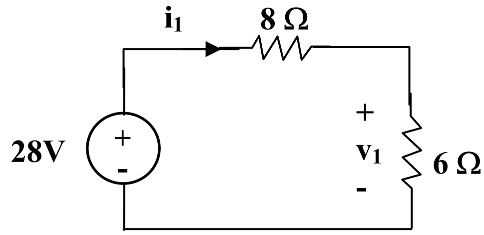
Chapter 2, Solution 34

By parallel and series combinations, the circuit is reduced to the one below:

$$10\|(2+13) = \frac{10x15}{25} = 6\Omega$$

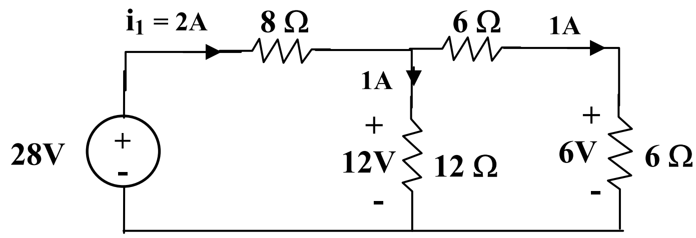
$$15\|(4+6) = \frac{15x15}{25} = 6\Omega$$

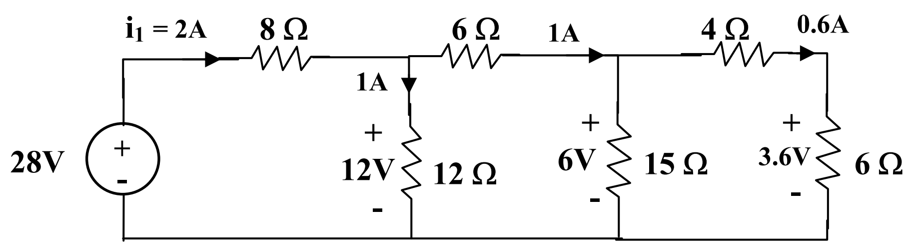
$$12\|(6+6) = 6\Omega$$



Thus $i_1 = \frac{28}{8+6} = 2$ A and $v_1 = 6i_1 = 12$ V

We now work backward to get i_2 and v_2.



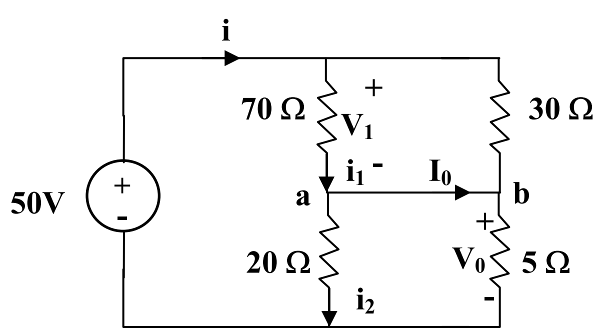


Thus, $v_2 = \frac{13}{15}(3\cdot 6) = 3\cdot 12,\ i_2 = \frac{v_2}{13} = 0.24$

$p_2 = i^2R = (0.24)^2\ (2) = 0.1152$ W

$i_1 =$ **2 A**, $i_2 =$ **0.24 A**, $v_1 =$ **12 V**, $v_2 =$ **3.12 V**, $p_2 =$ **0.1152 W**

Chapter 2, Solution 35



Combining the versions in parallel,

$$70 \| 30 = \frac{70x30}{100} = 21\Omega \ , \qquad 20 \| 15 = \frac{20x5}{25} = 4\ \Omega$$

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

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

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

At node a, KCL must be satisfied

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

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

Chapter 2, Solution 36

The 8-Ω resistor is shorted. No current flows through the 1-Ω resistor. Hence v_0 is the voltage across the 6Ω resistor.

$$I_0 = \frac{4}{2 + 3 \| 16} = \frac{4}{4} = 1\ A$$

$$v_0 = I_0\ (3 \| 6) = 2I_0\ =\ \mathbf{2\ V}$$

Chapter 2, Solution 37

Let I = current through the 16Ω resistor. If 4 V is the voltage drop across the $6\|R$ combination, then 20 - 4 = 16 V in the voltage drop across the 16Ω resistor.

Hence, $I = \frac{16}{16} = 1$ A.

But $I = \frac{20}{16 + 6\|R} \longrightarrow 1$ $\qquad 4 = 6\|R = \frac{6R}{6+R} \longrightarrow$ $\qquad$ R = **<u>12 Ω</u>**

Chapter 2, Solution 38

Let I_0 = current through the 6Ω resistor. Since 6Ω and 3Ω resistors are in parallel.

$6I_0 = 2 \text{ x } 3 \longrightarrow R_0 = 1$ A

The total current through the 4Ω resistor = 1 + 2 = 3 A.

Hence

$v_S = (2 + 4 + 2\|3)$ (3 A) = **<u>24 V</u>**

$I = \frac{v_S}{10} =$ **<u>2.4 A</u>**

Chapter 2, Solution 39

(a) $R_{eq} = R\|0 = \underline{\mathbf{0}}$

(b) $R_{eq} = R\|R + R\|R = \frac{R}{2} + \frac{R}{2} = \underline{\mathbf{R}}$

(c) $R_{eq} = (R+R)\|(R+R) = 2R\|2R = \underline{\mathbf{R}}$

(d) $R_{eq} = 3R\|(R + R\|R) = 3R\|(R + \frac{1}{2}R)$

$$= \frac{3Rx\frac{3}{2}R}{3R + \frac{3}{2}R} = \underline{\mathbf{R}}$$

(e) $R_{eq} = R\|2R\|3R = 3R\| \left(\frac{R \cdot 2R}{3R}\right)$

$$= 3R\| \frac{2}{3}R = \frac{3Rx\frac{2}{3}R}{3R + \frac{2}{3}R} = \underline{\frac{6}{11}}R$$

Chapter 2, Solution 40

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

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

Chapter 2, Solution 41

Let R_0 = combination of three 12Ω resistors in parallel

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

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

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

or $R = \underline{\mathbf{16\ \Omega}}$

Chapter 2, Solution 42

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

(b) $R_{ab} = 2 + 4\|(5 + 3)\|8 + 5\|10\|(6 + 4) = 2 + 4\|4 + 5\|5 = 2 + 2 + 2.5 = \underline{\mathbf{6.5\ \Omega}}$

Chapter 2, Solution 43

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

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

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

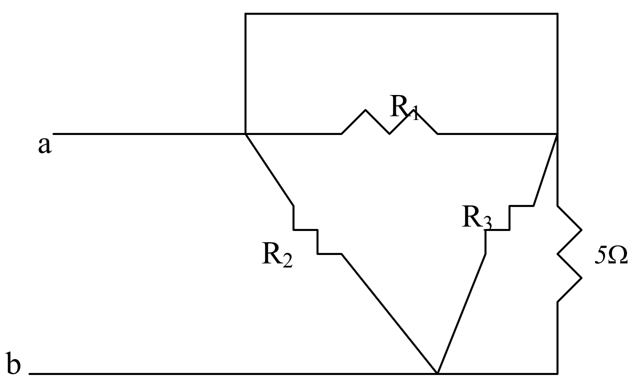
Chapter 2, Solution 44

(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.



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

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

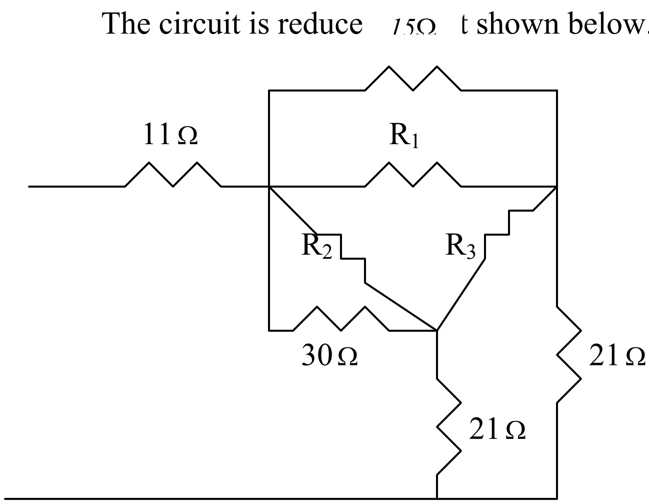
(b) 30//(20+50) = 30//70 = 21 Ω

Convert the T to Y and obtain

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

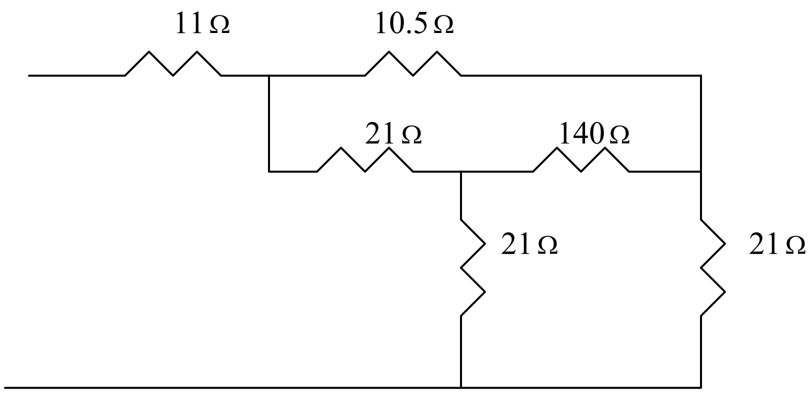
$$R_2 = \frac{1400}{20} = 70\Omega\,, \quad R_3 = \frac{1400}{10} = 140\Omega$$

The circuit is reduce t shown below.

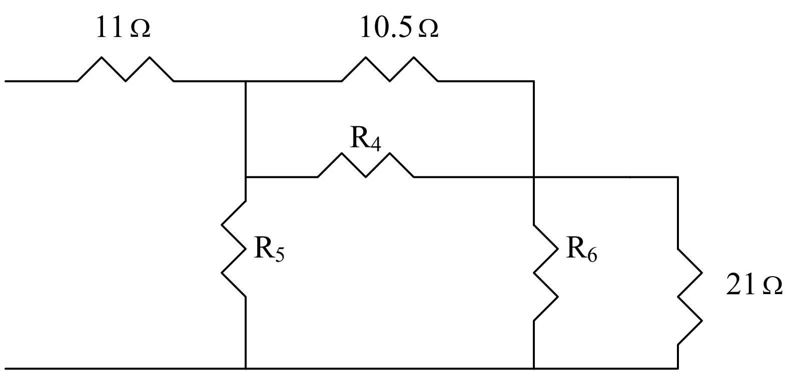


Combining the resistors in parallel

$R_1//15 = 35//15 = 10.5$, $30//R_2 = 30//70 = 21$
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, 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

(a) $R_{ab} = 30\|70 + 40 + 60\|20 = \frac{30x70}{100} + 40 + \frac{60+20}{80}$

$= 21 + 40 + 15 = \underline{\mathbf{76\ \Omega}}$

(b) The 10-Ω, 50-Ω, 70-Ω, and 80-Ω resistors are shorted.

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

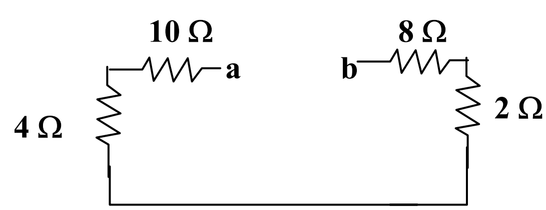
$40\|60 = \frac{40x60}{100} = 24$

$R_{ab} = 8 + 12 + 24 + 6 + 0 + 4 = \underline{\mathbf{54\ \Omega}}$

Chapter 2, Solution 47

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

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



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

Chapter 2, Solution 48

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

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

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

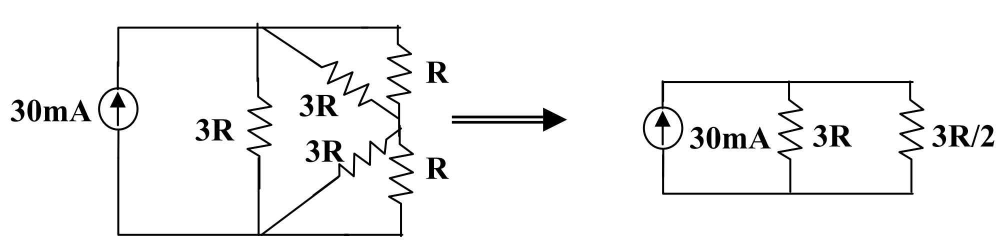
$$R_2 = \frac{60x10}{100} = 6\Omega$$

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

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

Chapter 2, Solution 50

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



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

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

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

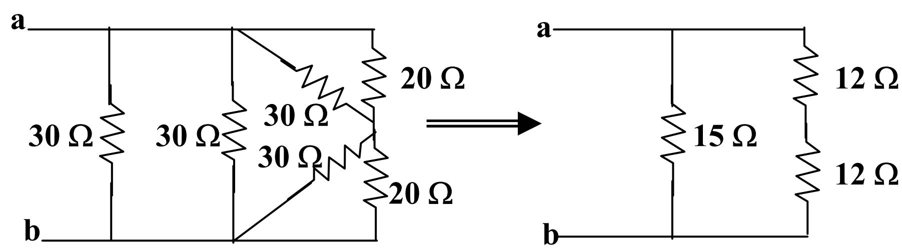
$P = I^2R \longrightarrow 800 \text{ x } 10^{-3} = (30 \text{ x } 10^{-3})^2 R$

R = **<u>889 Ω</u>**

Chapter 2, Solution 51

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

$R_{ab} = 15\|(12+12) = 15x24/(39) =$ **<u>9.31 Ω</u>**



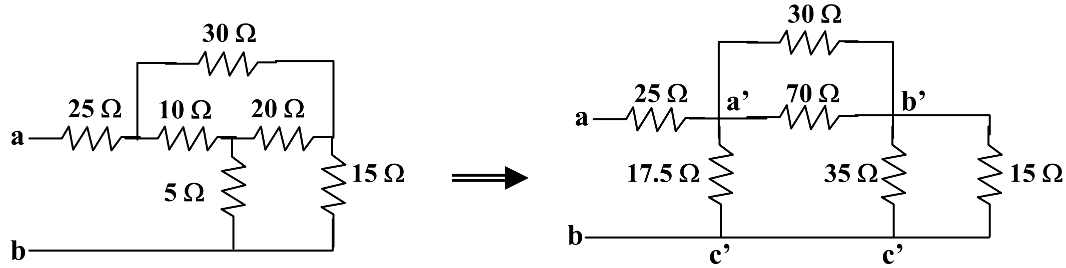
(b) Converting the T-subnetwork into its equivalent Δ network gives

$R_{a'b'}$ = 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

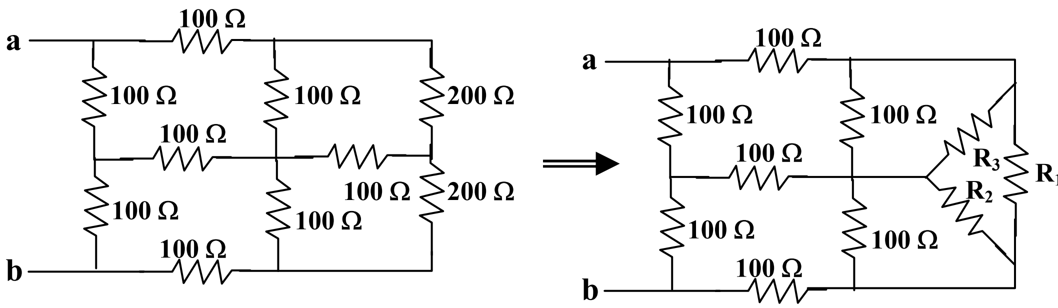
$R_{ab} = 25 + 17.5\|(21+10.5) = 25 + 17.5\|31.5$

$R_{ab} =$ **<u>36.25 Ω</u>**



Chapter 2, Solution 52

(a) We first convert from T to Δ.

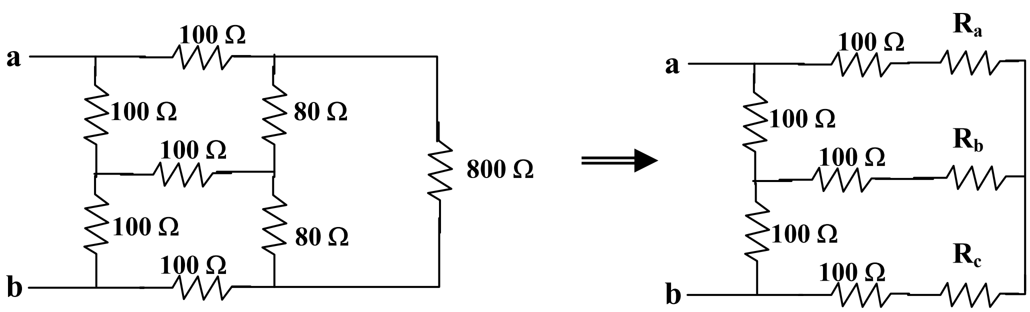


$$R_1 = \frac{100x200 + 200x200 + 200x100}{100} = \frac{80000}{100} = 800\Omega$$

$R_2 = R_3 = 80000/(200) = 400$

But $\quad 100 \| 400 = \dfrac{100x400}{500} = 80\Omega$

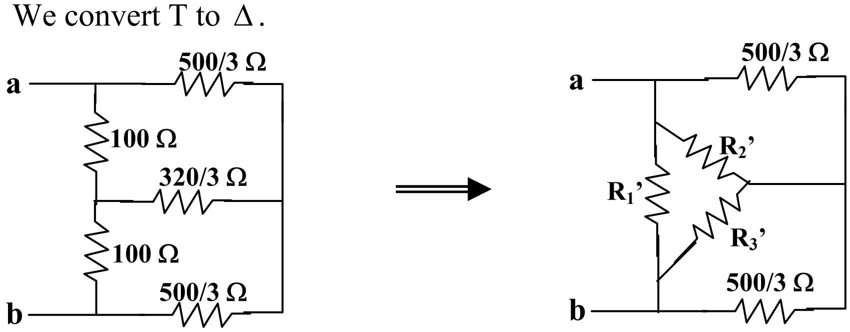
We connect the Δ to Y.



$$R_a = R_c = \frac{80x800}{80 + 80 + 800} = \frac{64,000}{960} = \frac{400}{3}\Omega$$

$$R_b = \frac{80x80}{960} = \frac{20}{3}\Omega$$

We convert T to Δ.



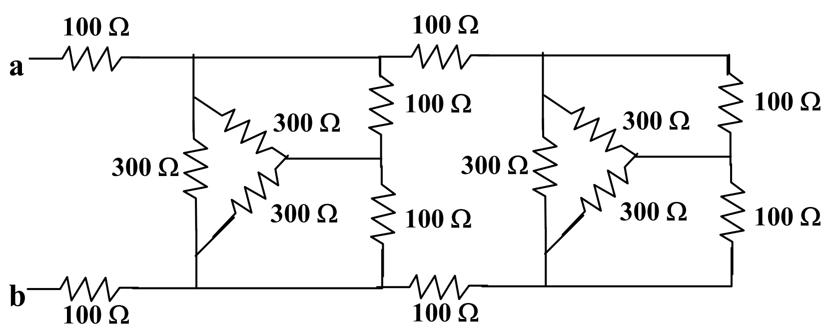
$$R_1^{'} = \frac{100x100 + 100x\frac{320}{3} + 100x\frac{320}{3}}{\frac{320}{3}} = \frac{94,000/(3)}{320/(3)} = 293.75\Omega$$

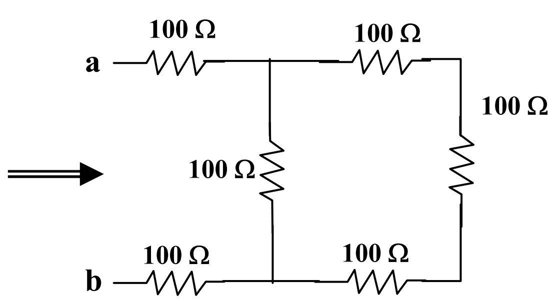
$$R_2^{'} = R_3^{1} = \frac{94,000/(3)}{100} = 313.33$$

$$940/(30)\|500/(3) = \frac{940/(3)x500/(3)}{1440/(3)} = 108.796$$

$$R_{ab} = 293.75\|(2x108.796) = \frac{293.75x217.6}{511.36} = \underline{\mathbf{125\ \Omega}}$$

(b) Converting the T_s to Δ_s, we have the equivalent circuit below.

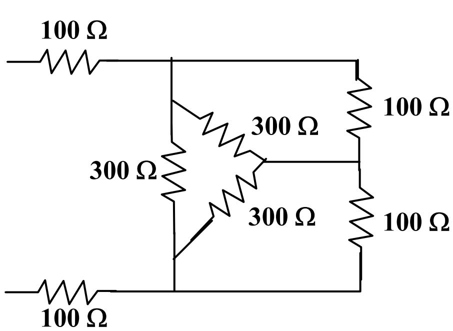




$$300\|100 = 300x100/(400) = 75, \quad 300\|(75+75) = 300x150/(450) = 100$$

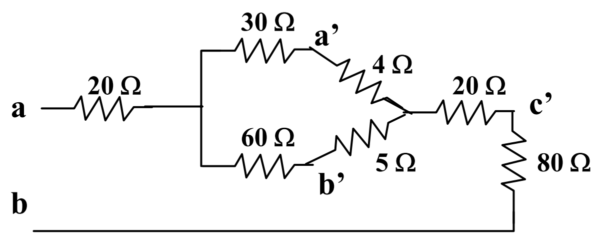
$$R_{ab} = 100 + 100\|300 + 100 = 200 + 100x300/(400)$$

$\underline{\mathbf{R_{ab} = 2.75\ \Omega}}$



Chapter 2, Solution 53

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



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

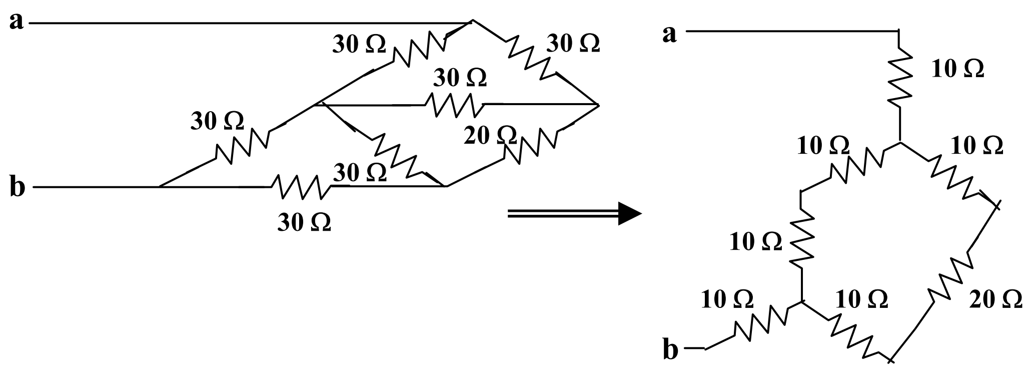
$R_{ab} = 20 + 80 + 20 + (30+4)\|(60+5) = 120 + 34\|65$

$R_{ab} =$ **<u>142.32 Ω</u>**

(a) 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:



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

<u>R_{ab} = 33.33 Ω</u>

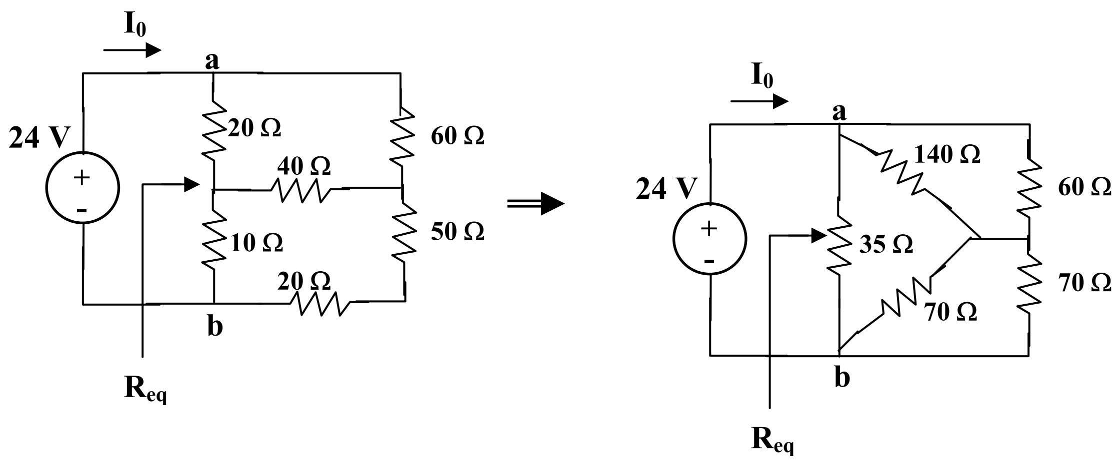
Chapter 2, Solution 54

(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.



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

$R_{ac} = 1400/(10) = 140\Omega$, $R_{bc} = 1400/(40) = 35\Omega$

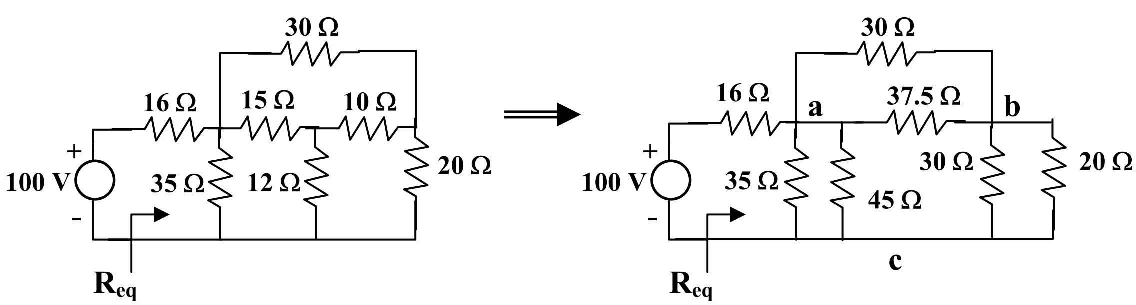
$70\|70 = 35$ and $140\|160 = 140x60/(200) = 42$

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

$I_0 = 24/(R_{ab}) =$ **0.9774A**

Chapter 2, Solution 56

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



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

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

Combining the resistors in parallel,

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

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

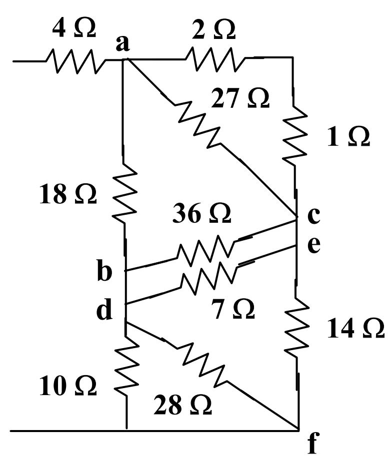
$$35||45 = (35x45/80) = 19.688\ \Omega$$

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

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

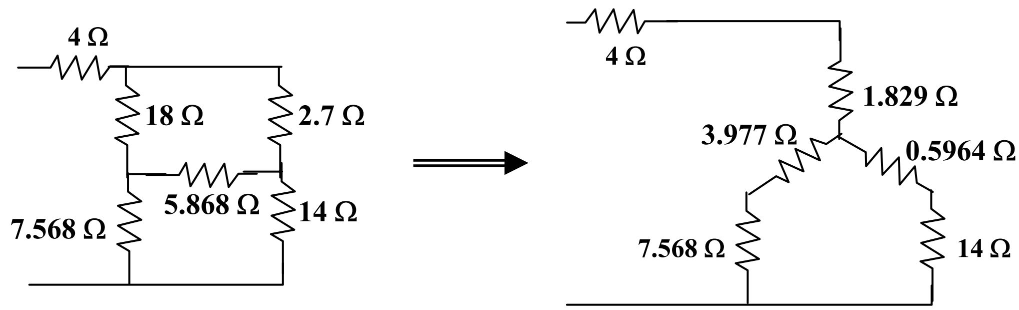
$$R_{de} = \frac{4x2+2x8+8x4}{8} = \frac{56}{8}7\ \Omega$$

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

Combining resistors in parallel,

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

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



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

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

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

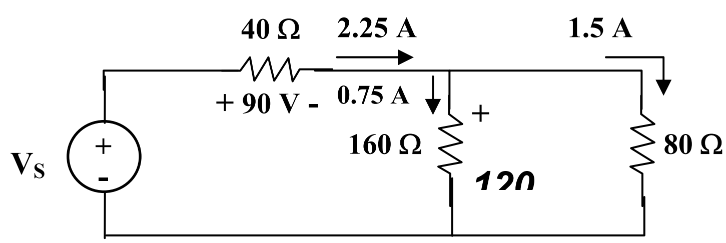
$$R_{eq} = 4 + 1.829 + (3.977 + 7.368)\|(0.5964 + 14)$$

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

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

Chapter 2, Solution 58

The resistor of the bulb is 120/(0.75) = 160Ω



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 x 40 = 90

Thus

$v_s = 90 + 120 =$ **210 V**

Chapter 2, Solution 59

Total power p = 30 + 40 + 50 + 120 W = vi

or i = p/(v) = 120/(100) = **1.2 A**

Chapter 2, Solution 60

p = iv i = p/(v)
i_{30W} = 30/(100) = **0.3 A**
i_{40W} = 40/(100) = **0.4 A**
i_{50W} = 50/(100) = **0.5 A**

Chapter 2, Solution 61

There are three possibilities

(a) Use R_1 and R_2:
$R = R_1 \| R_2 = 80 \| 90 = 42.35\Omega$
$p = i^2R$
i = 1.2A + 5% = 1.2 ± 0.06 = 1.26, 1.14A
p = 67.23W or 55.04W, cost = $1.50

(b) Use R_1 and R_3:
$R = R_1 \| R_3 = 80 \| 100 = 44.44\ \Omega$
$p = I^2R$ = 70.52W or 57.76W, cost = $1.35

(c) Use R_2 and R_3:
$R = R_2 \| R_3 = 90 \| 100 = 47.37\Omega$
$p = I^2R$ = 75.2W or 61.56W, cost = $1.65

Note that cases (b) and (c) give p that exceed 70W that can be supplied.
Hence case (a) is the right choice, i.e.

R_1 and R_2

Chapter 2, Solution 62

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

Energy cost = $0.06 x 360 x10 x (880 + 220)/1000 = $237.60

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

$p = I_n^2 R = (4.998)^2 (0.04) = 0.9992 \cong$ **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, $i_x = 1A$ ⟶ $R + R_x = \frac{110}{1} = 110\ \Omega$

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

Thus, R = **11 Ω**, 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

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

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

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

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

(b) $p = I_{fs}^2 R_n = (50\ \mu A)^2 (800\ k\Omega) =$ **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) $$\% \text{ error} = \left|\frac{v_0 - v_0'}{v_0}\right| \times 100\% = \frac{1.143}{4} x100 = \mathbf{28.57\%}$$

(d) $4k \| 30\ k\Omega = 3.6\ k\Omega$. By current division,

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

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

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

Chapter 2, Solution 68

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

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

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

(c) $$\% \text{ error} = \frac{0.1 - 0.09756}{0.1} x100\% = \mathbf{2.44\%}$$

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

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

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

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

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

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

(c) When R_2 = 100 kΩ, $R_2 \| R_m = 50$kΩ

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

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

Chapter 2, Solution 70

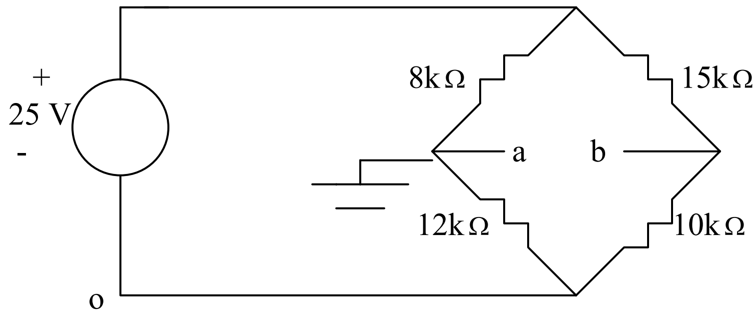
(a) Using voltage division,

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

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

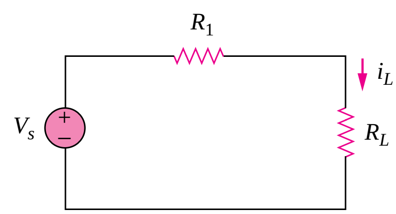
$$v_{ab} = v_a - v_b = 15 - 10 = \underline{5V}$$

(b)



$v_a = 0, \quad v_b = \underline{10V}, \quad v_{ab} = v_a - v_b = 0 - 10 = \underline{-10V}$

Chapter 2, Solution 71

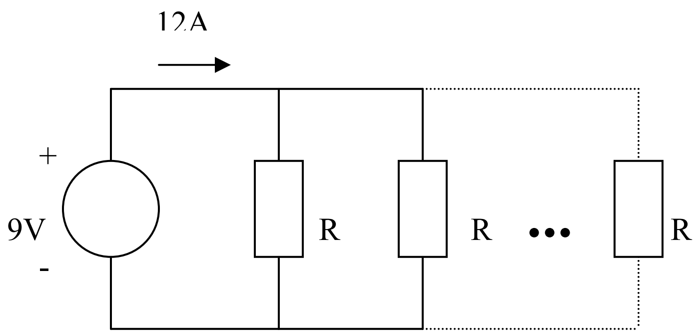


Given that $v_s = 30$ **V**, $R_1 = 20\ \Omega$, $I_L = 1$ **A**, find R_L.

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

Chapter 2, Solution 72

The system can be modeled as shown.



The n parallel resistors R give a combined resistance of R/n. Thus,

$$9 = 12x\frac{R}{n} \longrightarrow n = \frac{12xR}{9} = \frac{12x15}{9} = \underline{20}$$

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, 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,

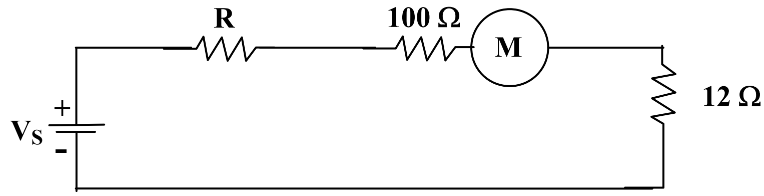
$6 = (0.01 + R_2 + R_3 + 0.02) \times 3 \longrightarrow R_2 + R_3 = 1.97$

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, Solution 75



(a) When $R_x = 0$, then

$$I_m = I_{fs} = \frac{t}{R + R_m} \longrightarrow R_2 = \frac{E^2}{I_{fs}} - R_m = \frac{2}{0.1x10^3} - 100 = 19.9k\Omega$$

(b) For half-scale deflection, $I_m = \frac{I_{fs}}{2} = 0.05mA$

$$I_m = \frac{E}{R + R_m + R_x} \longrightarrow R_x = \frac{E}{I_m} - (R + R_m) = \frac{2}{0.05x10^{-3}} - 20k\Omega = \underline{\mathbf{20\ k\Omega}}$$

Chapter 2, Solution 76

For series connection, R = 2 x 0.4Ω = 0.8Ω

$$p = \frac{V^2}{R} = \frac{(120)^2}{0.8} = \underline{\mathbf{18\ k\Omega}} \quad \mathbf{(low)}$$

For parallel connection, R = 1/2 x 0.4Ω = 0.2Ω

$$p = \frac{V^2}{R} = \frac{(120)^2}{0.2} = \underline{\mathbf{72\ kW}} \quad \mathbf{(high)}$$

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

(c) $40k\Omega = 12k\Omega + 28k\Omega = 24\|24k + 56k\|50k$

i.e., Two 24kΩ resistors in parallel **<u>connected in series with two 50kΩ resistors in parallel</u>.**

(d) $42.32k\Omega = 42l + 320$

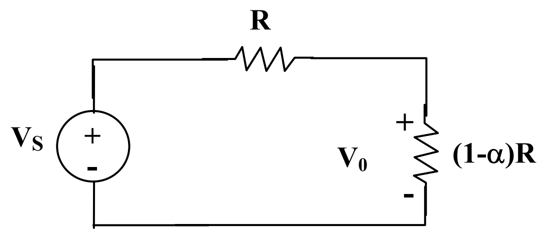
$= 24k + 28k = 320$

$= 24k = 56k\|56k + 300 + 20$

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

Chapter 2, Solution 78

The equivalent circuit is shown below:



$$V_0 = \frac{(1-\alpha)R}{R+(1-\alpha)R} V_S = (1-\alpha)R_0 V_S$$

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

Chapter 2, Solution 79

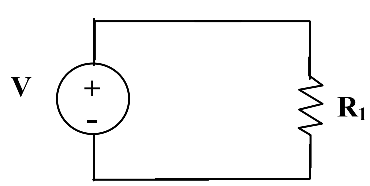
Since $p = v^2/R$, the resistance of the sharpener is
$R = v^2/(p) = 6^2/(240 \times 10^{-3}) = 150\Omega$
$I = p/(v) = 240\text{ mW}/(6V) = 40\text{ mA}$

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

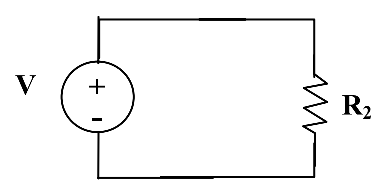
$IR_x = V_x = 9 - 6 = 3\text{ V}$
$R_x = 3/(I) = 3/(40\text{ mA}) = 3000/(40) =$ **75 Ω**

Chapter 2, Solution 80

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



Case 1



Case 2

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

Chapter 2, Solution 81

Let R_1 and R_2 be in kΩ.

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

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

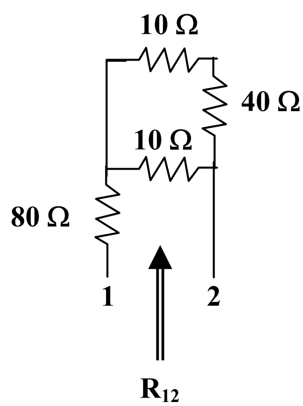
From (1) and (2), $0.05 = \frac{5\|R_1}{40} \rightarrow \quad 2 = 5\|R_2 = \frac{5R_2}{5+R_2}$ or $R_2 = 3.33$ kΩ

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

Thus **$R_1 = 38$ kΩ, $R_2 = 3.33$ kΩ**

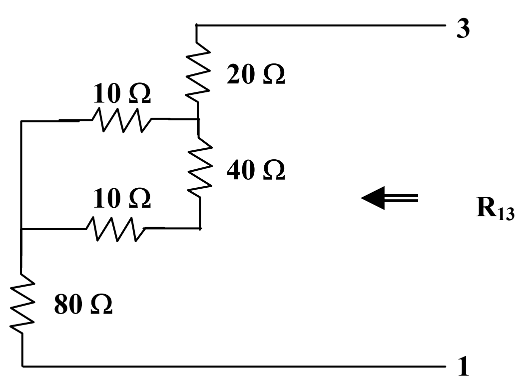
Chapter 2, Solution 82

(a)



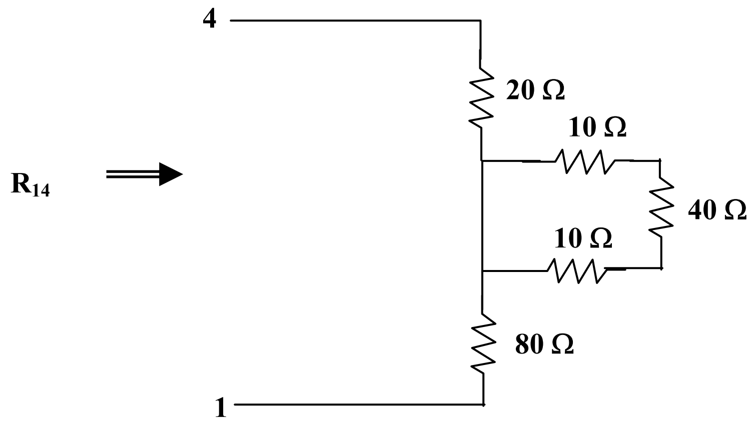
$$R_{12} = 80 + 10\|(10+40) = 80 + \frac{50}{6} = \underline{\mathbf{88.33\ \Omega}}$$

(b)



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

(c)



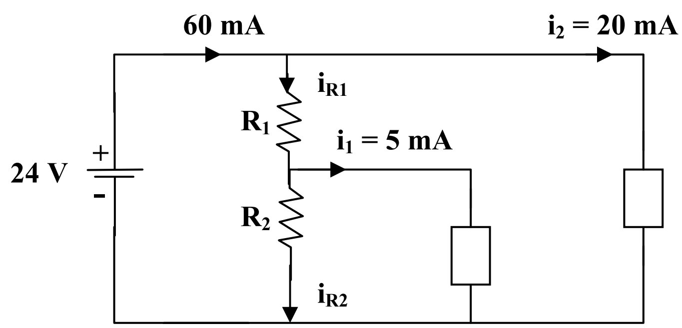
$$R_{14} = 80 + 0 \| (10 + 40 + 10) + 20 = 80 + 0 + 20 = \underline{\mathbf{100\ \Omega}}$$

Chapter 2, Solution 83

The voltage across the tube is 2 x 60 mV = 0.06 V, which is negligible compared with 24 V. Ignoring this voltage amp, we can calculate the current through the devices.

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

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



By applying KCL, we obtain

$$I_{R_1} = 60 - 20 = 40 \text{ mA} \text{ and } I_{R_2} = 40 - 5 = 35 \text{ mA}$$

Hence, $I_{R_1} R_1 = 24 - 9 = 15\text{ V} \longrightarrow R_1 = \frac{15\text{V}}{40\text{mA}} = \underline{\mathbf{375\ \Omega}}$

$$I_{R_2} R_2 = 9\text{V} \longrightarrow R_2 = \frac{9\text{V}}{35\text{mA}} = \underline{\mathbf{257.14\ \Omega}}$$