Chapter 4, Problem 1.

Calculate the current i_o in the circuit of Fig. 4.69. What does this current become when the input voltage is raised to 10 V?

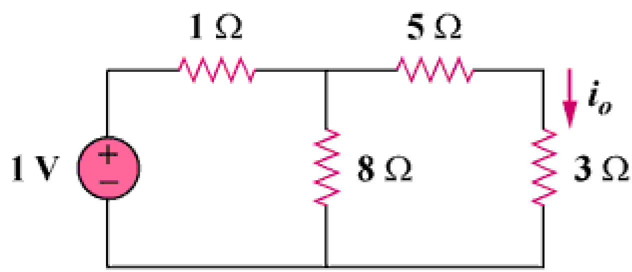
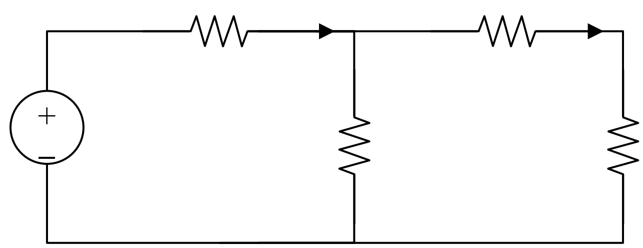


Figure 4.69

Chapter 4, Solution 1.



$8 \| (5+3) = 4\Omega$, $i = \frac{1}{1+4} = \frac{1}{5}$

$i_o = \frac{1}{2} i = \frac{1}{10} = \underline{\mathbf{0.1A}}$

Since the resistance remains the same we get i = 10/5 = 2A which leads to
$i_o = (1/2)i = (1/2)2 = \underline{\mathbf{1A}}$.

Chapter 4, Problem 2.

Find $\boldsymbol{v_o}$ in the circuit of Fig. 4.70. If the source current is reduced to 1 μA, what is $\boldsymbol{v_o}$?

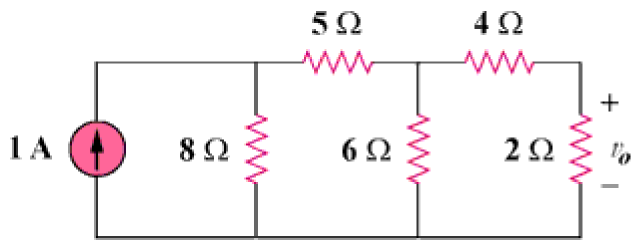
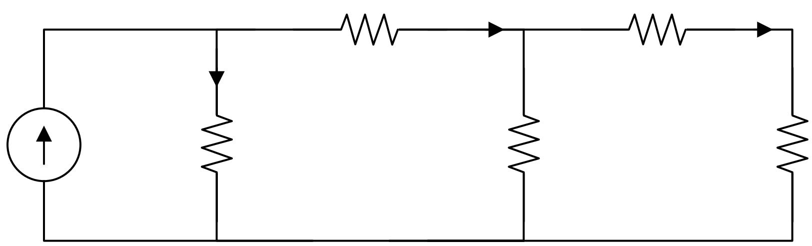


Figure 4.70

Chapter 4, Solution 2.

$$6\|(4+2) = 3\Omega, \quad i_1 = i_2 = \frac{1}{2}\text{A}$$

$$i_o = \frac{1}{2}i_1 = \frac{1}{4}, \quad v_o = 2i_o = \underline{\mathbf{0.5V}}$$



If $i_s = 1\mu$A, then v_o = $\underline{\mathbf{0.5\mu V}}$

Chapter 4, Problem 3.

(a) In the circuit in Fig. 4.71, calculate v_o and I_o when v_s = 1 V.
(b) Find v_o and i_o when v_s = 10 V.
(c) What are v_o and I_o when each of the 1-Ω resistors is replaced by a 10-Ω resistor and v_s = 10 V?

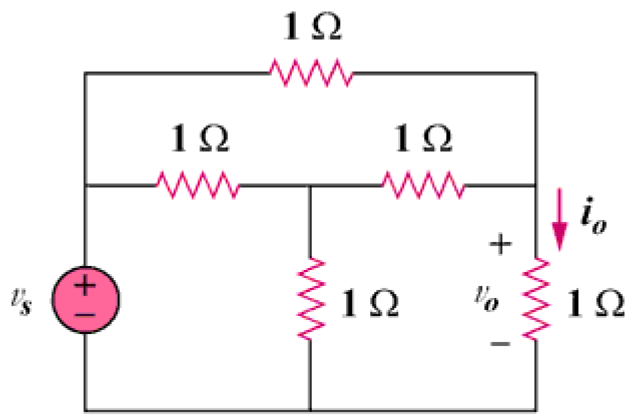
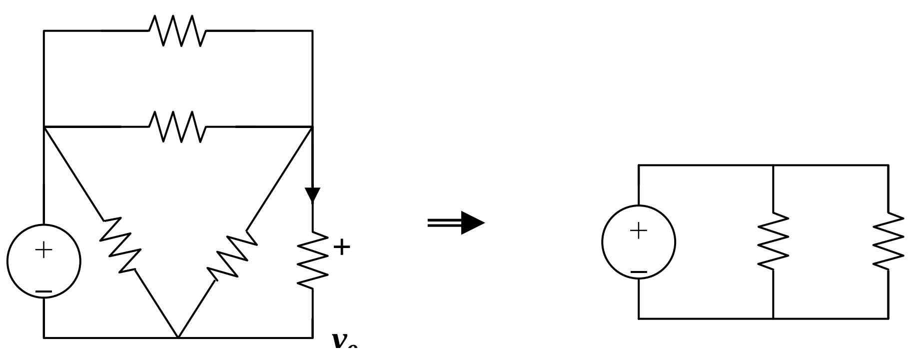


Figure 4.71

Chapter 4, Solution 3.



(a) We transform the Y sub-circuit to the equivalent Δ.

$$R \| 3R = \frac{3R^2}{4R} = \frac{3}{4}R, \quad \frac{3}{4}R + \frac{3}{4}R = \frac{3}{2}R$$

$$v_o = \frac{v_s}{2} \text{ independent of R}$$

$i_o = v_o/(R)$

When v_s = 1V, v_o = **0.5V**, i_o = **0.5A**

(b) When v_s = 10V, v_o = **5V**, i_o = **5A**

(c) When v_s = 10V and R = 10Ω,
v_o = **5V**, i_o = 10/(10) = **500mA**

Chapter 4, Problem 4.

Use linearity to determine i_o in the circuit in Fig. 4.72.

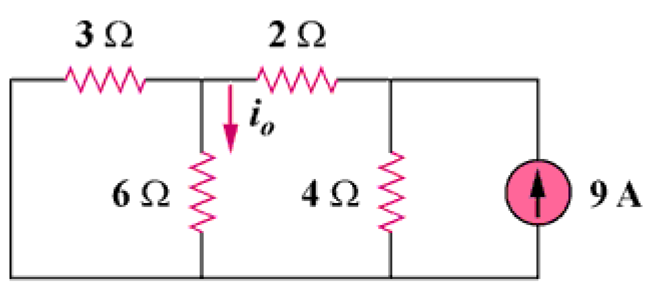
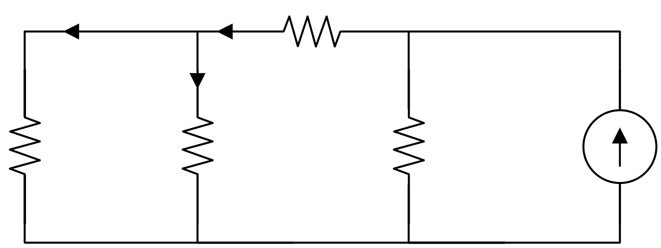
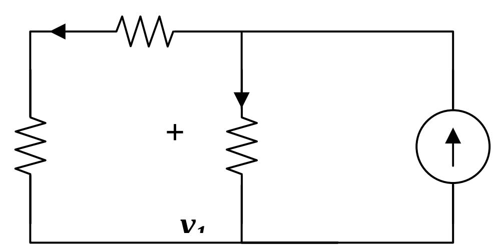


Figure 4.72

Chapter 4, Solution 4.

If $I_o = 1$, the voltage across the 6Ω resistor is 6V so that the current through the 3Ω resistor is 2A.





$3\|6 = 2\Omega$, $v_o = 3(4) = 12\text{V}$, $i_1 = \frac{v_o}{4} = 3\text{A}$.

Hence $I_s = 3 + 3 = 6\text{A}$

If $\quad I_s = 6\text{A} \longrightarrow I_o = 1$

$\quad\quad I_s = 9\text{A} \longrightarrow I_o = 9/6 = \underline{\mathbf{1.5A}}$

Chapter 4, Problem 5.

For the circuit in Fig. 4.73, assume v_o = 1 V, and use linearity to find the actual value of v_o.

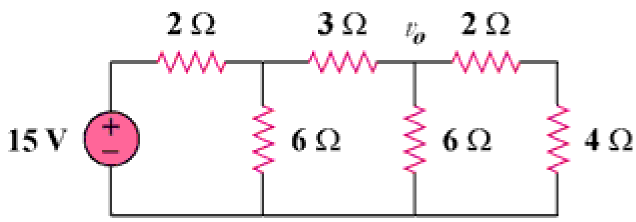
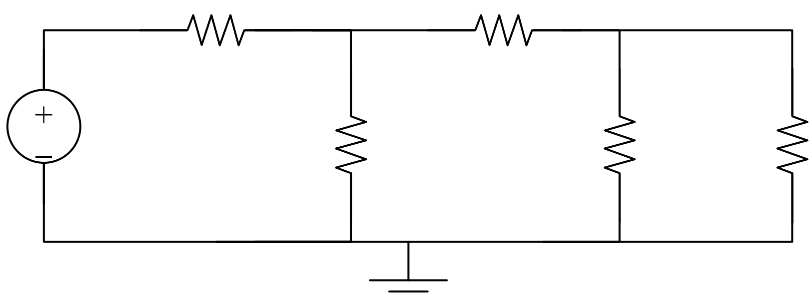


Figure 4.73

Chapter 4, Solution 5.



If v_o = 1V, $\quad V_1 = \left(\frac{1}{3}\right) + 1 = 2V$

$$V_s = 2\left(\frac{2}{3}\right) + v_1 = \frac{10}{3}$$

If $v_s = \frac{10}{3} \longrightarrow v_o = 1$

Then $v_s = 15 \longrightarrow \quad v_o = \frac{3}{10} x15 = \underline{\mathbf{4.5V}}$

Chapter 4, Problem 6.

For the linear circuit shown in Fig. 4.74, use linearity to complete the following table.

Experiment	V_s	V_o
1	12 V	4 V
2	--	16 V
3	1 V	--
4	--	-2V

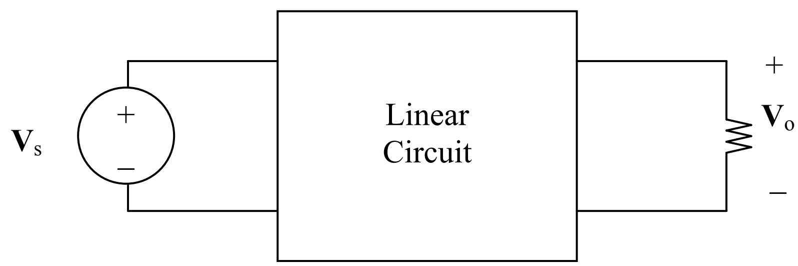


Figure 4.74 For Prob. 4.6.

Chapter 4, Solution 6.

Due to linearity, from the first experiment,

$$V_o = \frac{1}{3} V_s$$

Applying this to other experiments, we obtain:

Experiment	V_s	V_o
2	48	16 V
3	1 V	0.333 V
4	-6 V	-2V

Chapter 4, Problem 7.

Use linearity and the assumption that $V_o = 1V$ to find the actual value of V_o in Fig. 4.75.

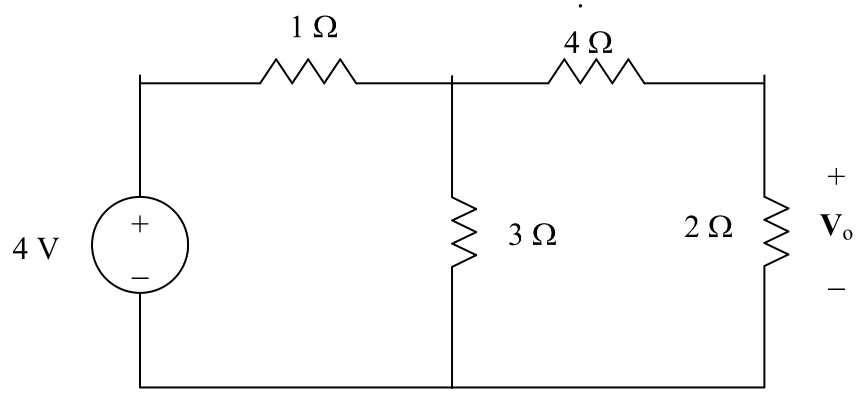


Figure 4.75 For Prob. 4.7.

Chapter 4, Solution 7.

If $V_o = 1V$, then the current through the 2-Ω and 4-Ω resistors is ½ = 0.5. The voltage across the 3-Ω resistor is ½ (4 + 2) = 3 V. The total current through the 1-Ω resistor is 0.5 +3/3 = 1.5 A. Hence the source voltage

$$v_s = 1x1.5 + 3 = 4.5 \text{ V}$$

If $v_s = 4.5 \longrightarrow 1V$

Then $v_s = 4 \longrightarrow \frac{1}{4.5} x4 = \underline{0.8889 \text{ V}}$ = **<u>888.9 mV</u>**.

Chapter 4, Problem 8.

Using superposition, find V_o in the circuit of Fig. 4.76.

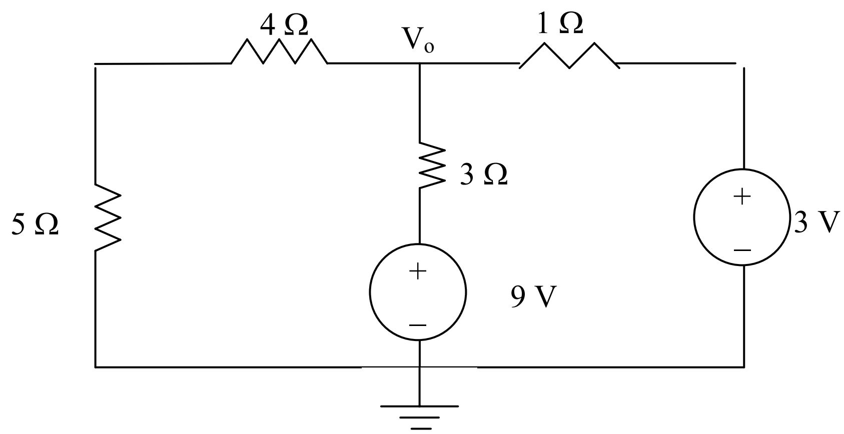
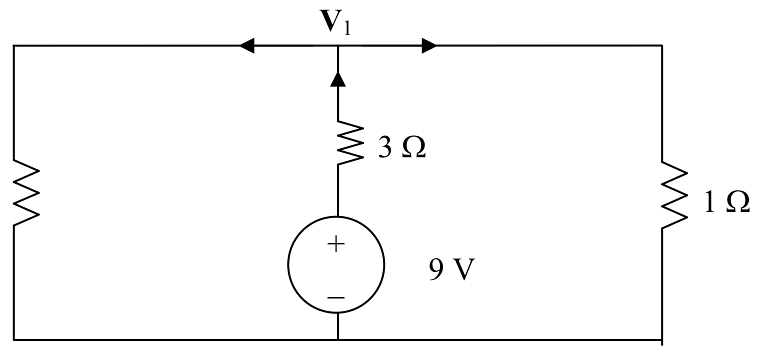


Figure 4.76 For Prob. 4.8.

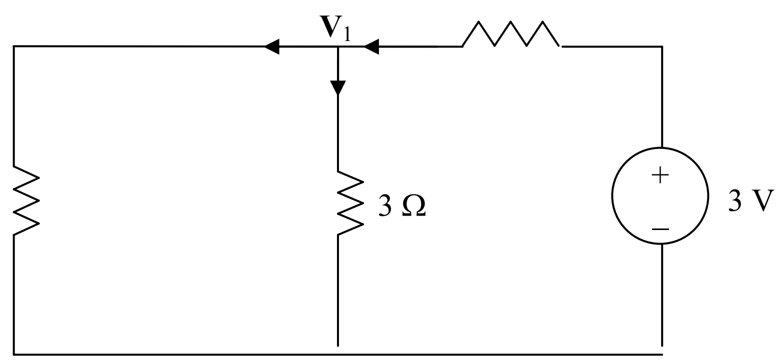
Chapter 4, Solution 8.

Let $V_o = V_1 + V_2$, where V_1 and V_2 are due to 9-V and 3-V sources respectively. To find V_1, consider the circuit below.



$$\frac{9-V_1}{3} = \frac{V_1}{9} + \frac{V_1}{1} \longrightarrow V_1 = 27/13 = 2.0769$$

To find V_2, consider the circuit below.



$$\frac{V_2}{9} + \frac{V_2}{3} = \frac{3-V_2}{1} \longrightarrow V_2 = 27/13 = 2.0769$$

$$V_o = V_1 + V_2 = \underline{\mathbf{4.1538\ \ V}}$$

Chapter 4, Problem 9.

Use superposition to find v_o in the circuit of Fig. 4.77.

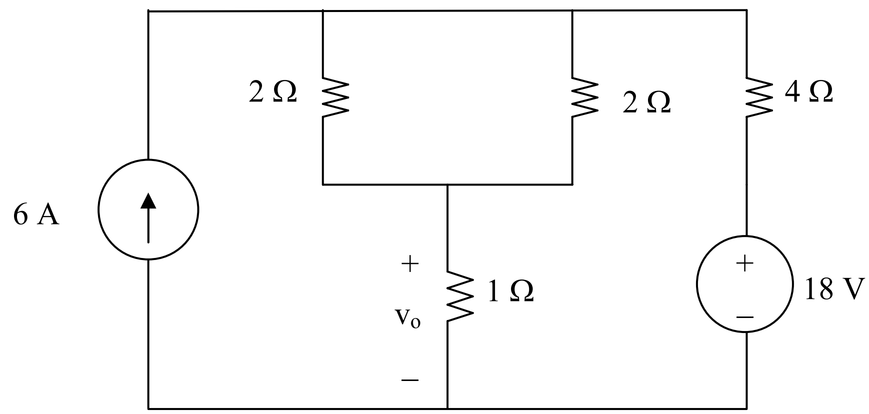
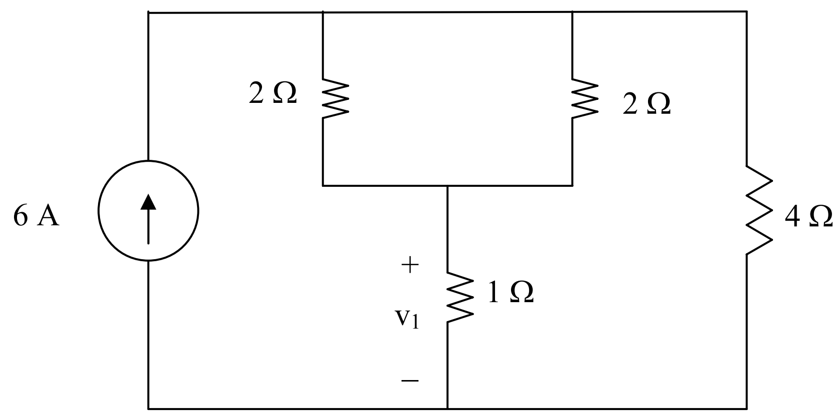


Figure 4.77 For Prob. 4.9.

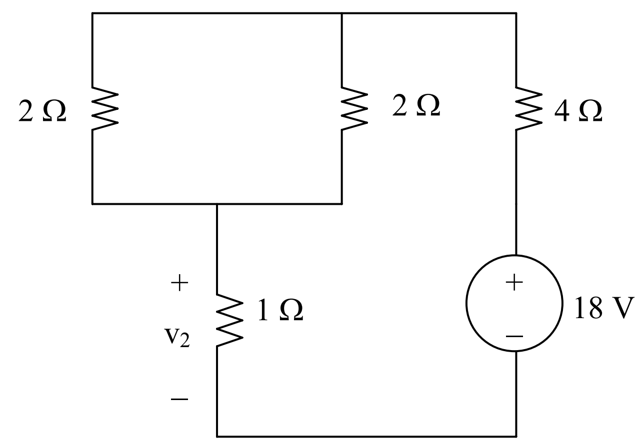
Chapter 4, Solution 9.

Let $v_o = v_1 + v_2$, where v_1 and v_2 are due to 6-A and 20-V sources respectively. We find v_1 using the circuit below.



2//2 = 1 Ω, $v_1 = 1x\frac{4}{4+2}(6A) = 4\text{ V}$

We find v_2 using the circuit below.



$$v_2 = \frac{1}{1+1+4}(18) = 3\text{ V}$$

$v_o = v_1 + v_2 = 4 + 3 =$ **7 V**

Chapter 4, Problem 10.

For the circuit in Fig. 4.78, find the terminal voltage V_{ab} using superposition.

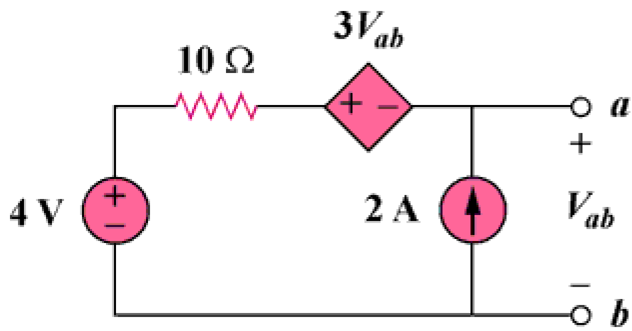
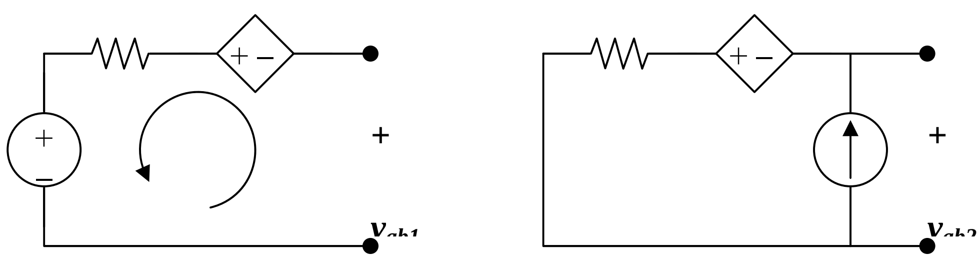


Figure 4.78

Chapter 4, Solution 10.

Let $v_{ab} = v_{ab1} + v_{ab2}$ where v_{ab1} and v_{ab2} are due to the 4-V and the 2-A sources respectively.



For v_{ab1}, consider Fig. (a). Applying KVL gives,

$$- v_{ab1} – 3\ v_{ab1} + 10x0 + 4 = 0, \text{ which leads to } v_{ab1} = 1\text{ V}$$

For v_{ab2}, consider Fig. (b). Applying KVL gives,

$$- \quad v_{ab2} – 3v_{ab2} + 10x2 = 0, \text{ which leads to } v_{ab2} = 5$$

$$v_{ab} = 1 + 5 = \underline{\mathbf{6\ V}}$$

Chapter 4, Problem 11.

Use the superposition principle to find i_o and v_o in the circuit of Fig. 4.79.

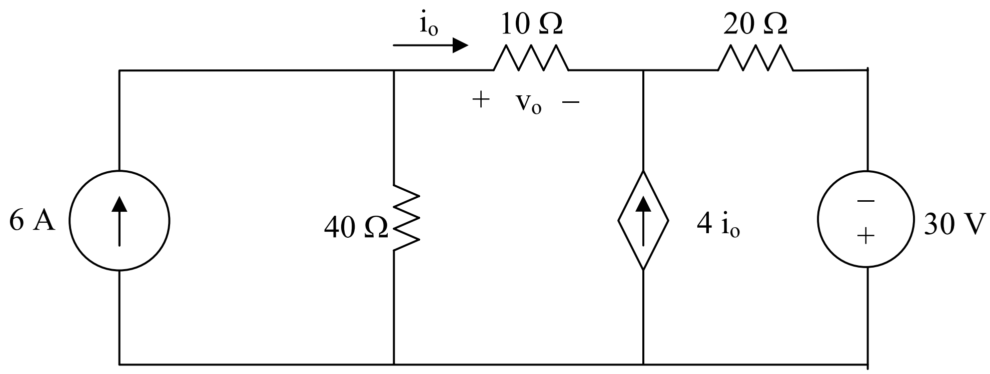
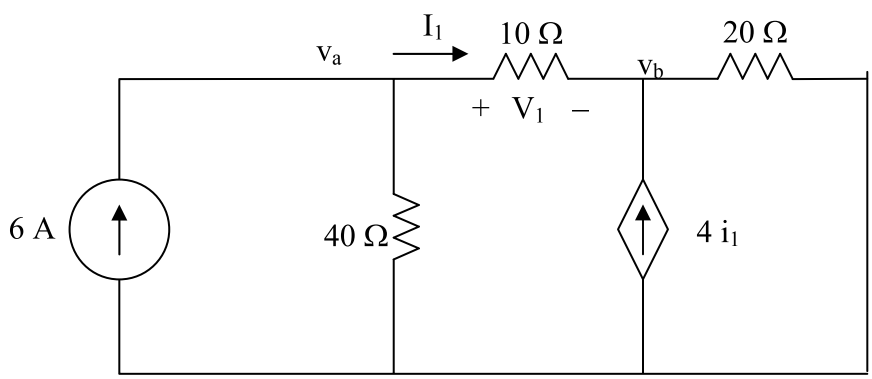


Figure 4.79 For Prob. 4.11.

Chapter 4, Solution 11.

Let $v_o = v_1 + v_2$, where v_1 and v_2 are due to the 6-A and 80-V sources respectively. To find v_1, consider the circuit below.



At node a,

$$6 = \frac{v_a}{40} + \frac{v_a - v_b}{10} \longrightarrow 240 = 5v_a - 4v_b \qquad (1)$$

At node b,

$$-I_1 - 4I_1 + (v_b - 0)/20 = 0 \text{ or } v_b = 100I_1$$

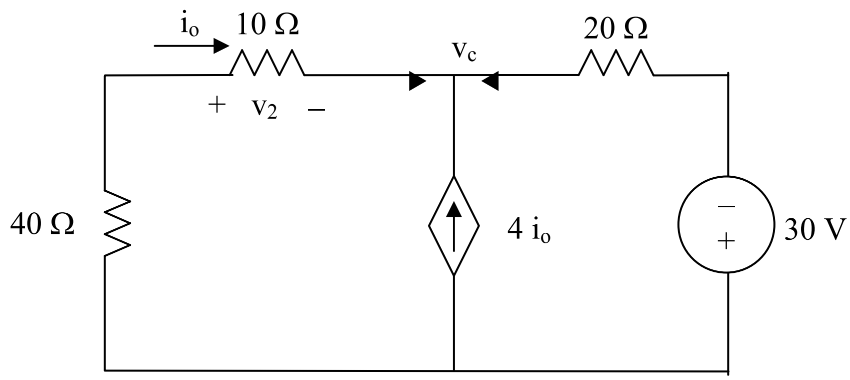
But $i_1 = \dfrac{v_a - v_b}{10}$ which leads to $100(v_a - v_b)10 = v_b$ or $v_b = 0.9091v_a$ (2)

Substituting (2) into (1),

$$5v_a - 3.636v_a = 240 \text{ or } v_a = 175.95 \text{ and } v_b = 159.96$$

However, $v_1 = v_a - v_b = 15.99$ V.

To find v_2, consider the circuit below.



$$\frac{0 - v_c}{50} + 4i_o + \frac{(-30 - v_c)}{20} = 0$$

But $i_o = \dfrac{(0 - v_c)}{50}$

$$-\frac{5v_c}{50} - \frac{(30 + v_c)}{20} = 0 \longrightarrow v_c = -10 \text{ V}$$

$$i_2 = \frac{0 - v_c}{50} = \frac{0 + 10}{50} = \frac{1}{5}$$

$$v_2 = 10i_2 = 2 \text{ V}$$

$v_o = v_1 + v_2 = 15.99 + 2 =$ **17.99 V** and $i_o = v_o/10 =$ **1.799 A**.

Chapter 4, Problem 12.

Determine v_o in the circuit in Fig. 4.80 using the superposition principle.

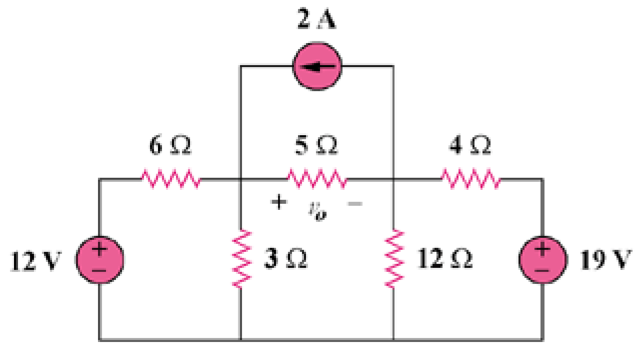
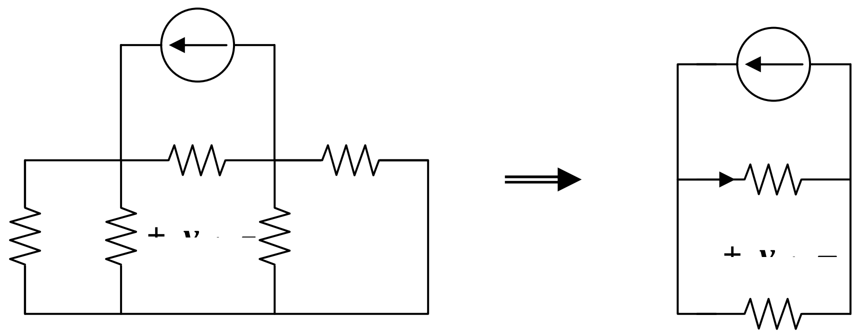


Figure 4.80

Chapter 4, Solution 12.

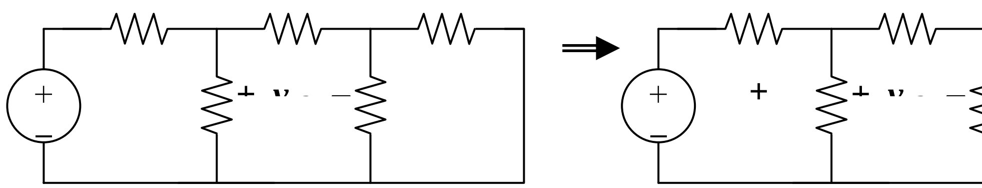
Let $v_o = v_{o1} + v_{o2} + v_{o3}$, where v_{o1}, v_{o2}, and v_{o3} are due to the 2-A, 12-V, and 19-V sources respectively. For v_{o1}, consider the circuit below.



$$6||3 = 2 \text{ ohms}, \quad 4||12 = 3 \text{ ohms. Hence,}$$

$$i_o = 2/2 = 1, \; v_{o1} = 5io = 5 \text{ V}$$

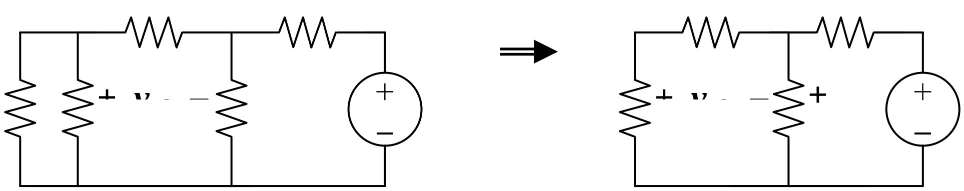
For v_{o2}, consider the circuit below.



$$3||8 = 24/11, \quad v_1 = [(24/11)/(6 + 24/11)]12 = 16/5$$

$$v_{o2} = (5/8)v_1 = (5/8)(16/5) = \underline{\mathbf{2\ V}}$$

For v_{o3}, consider the circuit shown below.



$$7||12 = (84/19) \text{ ohms}, \quad v_2 = [(84/19)/(4 + 84/19)]19 = 9.975$$

$$v = (-5/7)v2 = -7.125$$

$v_o = 5 + 2 – 7.125 = \underline{\mathbf{-125\ mV}}$

Chapter 4, Problem 13.

Use superposition to find v_o in the circuit of Fig. 4.81.

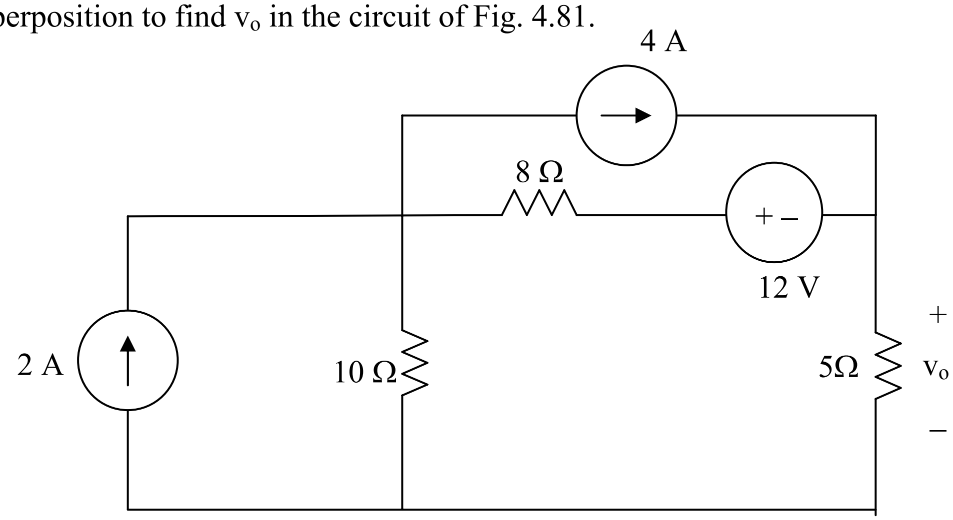
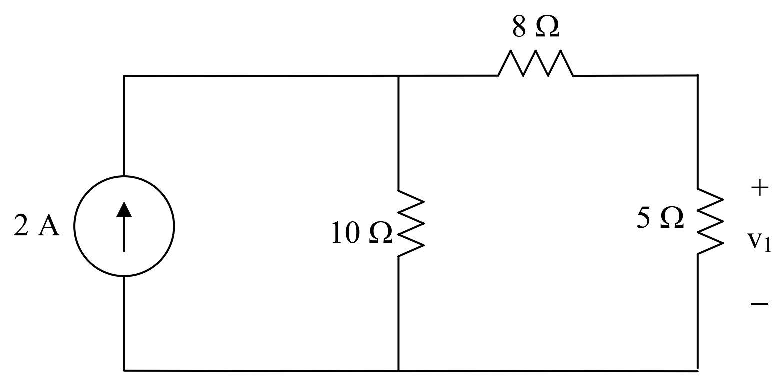


Figure 4.81 For Prob. 4.13.

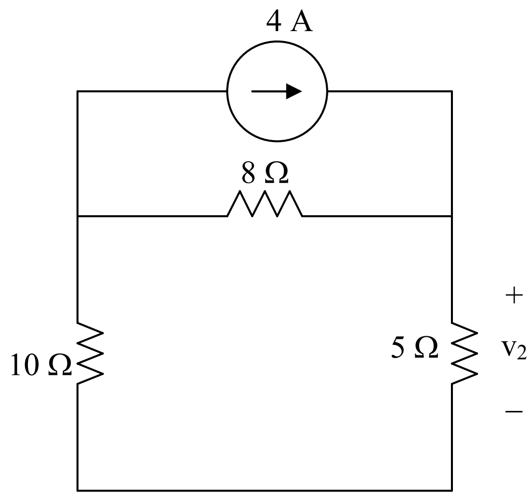
Chapter 4, Solution 13.

Let $v_o = v_1 + v_2 + v_3$, where v_1, v_2, and v_3 are due to the independent sources. To find v_1, consider the circuit below.



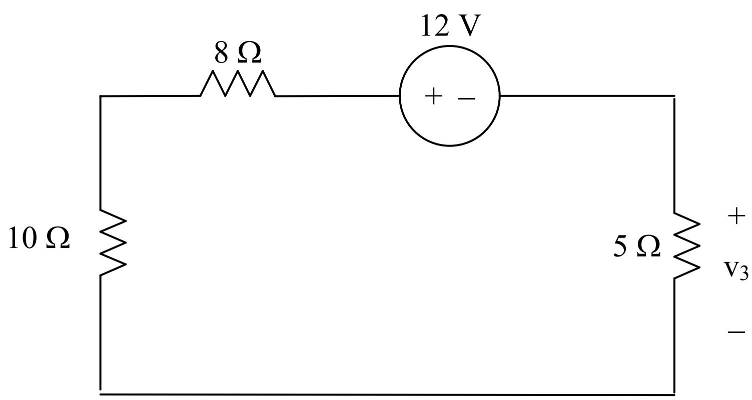
$$v_1 = 5x\frac{10}{10+8+5}x2 = 4.3478$$

To find v_2, consider the circuit below.



$$v_2 = 5x\frac{8}{8+10+5}x4 = 6.9565$$

To find v_3, consider the circuit below.



$$v_3 = -12\left(\frac{5}{5+10+8}\right) = -2.6087$$

$$v_o = v_1 + v_2 + v_3 = \underline{8.6956\ \text{V}} = \underline{\mathbf{8.696V}}.$$

Chapter 4, Problem 14.

Apply the superposition principle to find v_o in the circuit of Fig. 4.82.

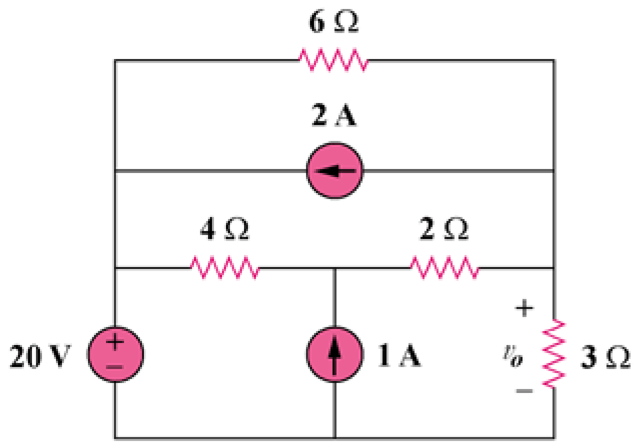
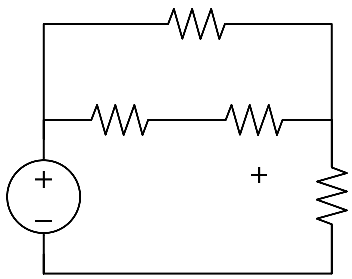


Figure 4.82

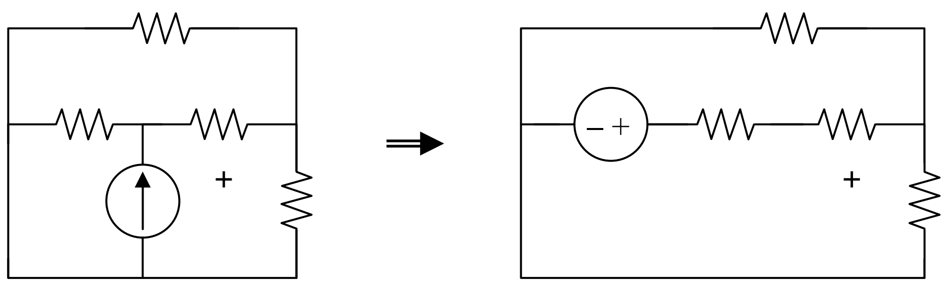
Chapter 4, Solution 14.

Let $v_o = v_{o1} + v_{o2} + v_{o3}$, where v_{o1}, v_{o2} , and v_{o3}, are due to the 20-V, 1-A, and 2-A sources respectively. For v_{o1}, consider the circuit below.



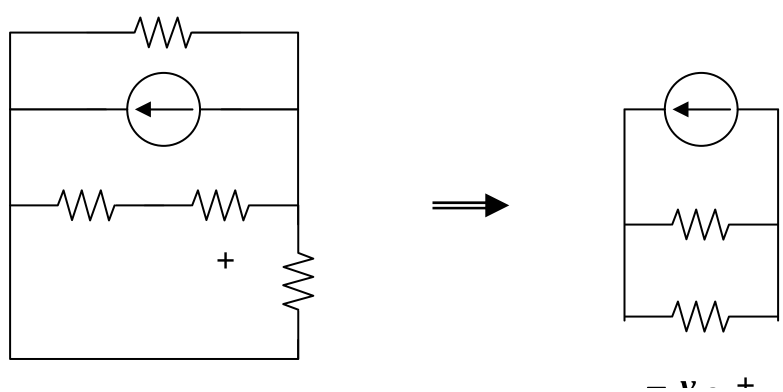
$$6||(4 + 2) = 3 \text{ ohms}, v_{o1} = (½)20 = 10 \text{ V}$$

For v_{o2}, consider the circuit below.



$$3||6 = 2 \text{ ohms}, v_{o2} = [2/(4 + 2 + 2)]4 = 1 \text{ V}$$

For v_{o3}, consider the circuit below.



$$6||(4 + 2) = 3, v_{o3} = (-1)3 = –3$$

$$v_o = 10 + 1 – 3 = \underline{\mathbf{8\ V}}$$

Chapter 4, Problem 15.

For the circuit in Fig. 4.83, use superposition to find ***i***. Calculate the power delivered to the 3-Ω resistor.

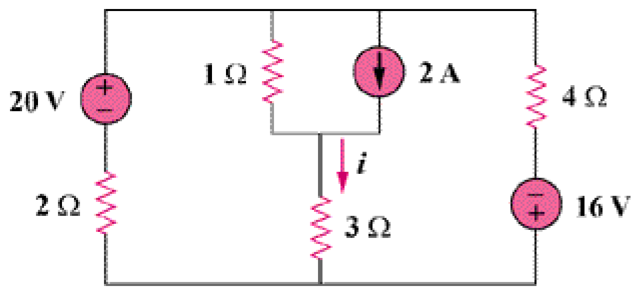
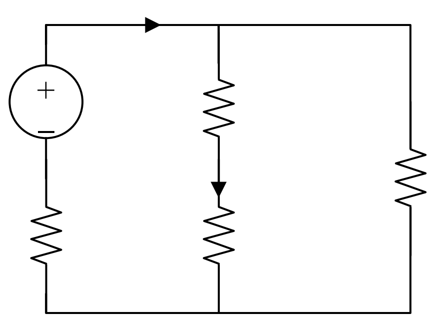


Figure 4.83

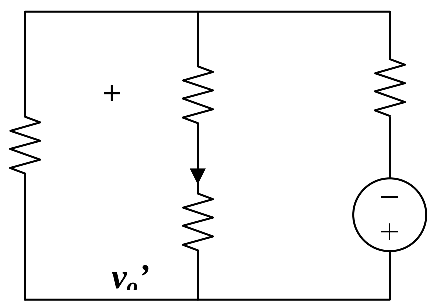
Chapter 4, Solution 15.

Let $i = i_1 + i_2 + i_3$, where i_1 , i_2 , and i_3 are due to the 20-V, 2-A, and 16-V sources. For i_1, consider the circuit below.



$$4||(3 + 1) = 2 \text{ ohms}, \text{ Then } i_o = [20/(2 + 2)] = 5 \text{ A}, \ i_1 = i_o/2 = 2.5 \text{ A}$$

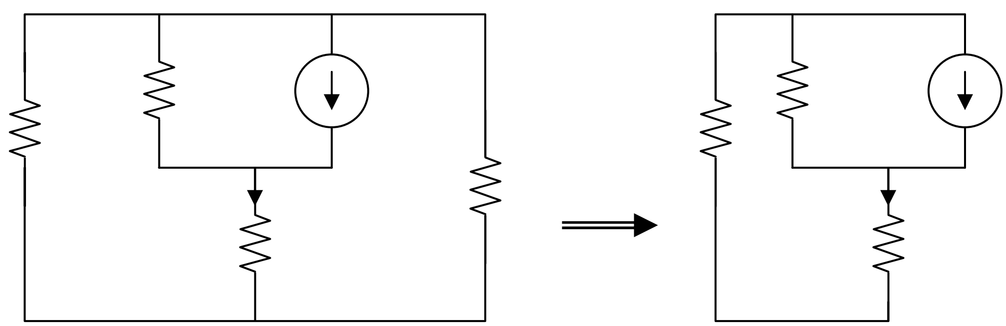
For i_3, consider the circuit below.



$$2||(1 + 3) = 4/3,\ v_o' = [(4/3)/((4/3) + 4)](-16) = -4$$

$$i_3 = v_o'/4 = -1$$

For i_2, consider the circuit below.



$$2||4 = 4/3,\ 3 + 4/3 = 13/3$$

Using the current division principle.

$$i_2 = [1/(1 + 13/2)]2 = 3/8 = 0.375$$

$$i = 2.5 + 0.375 - 1 = \underline{\mathbf{1.875\ A}}$$

$$p = i^2R = (1.875)^2 3 = \underline{\mathbf{10.55\ watts}}$$

Chapter 4, Problem 16.

Given the circuit in Fig. 4.84, use superposition to get $\boldsymbol{i_o}$.

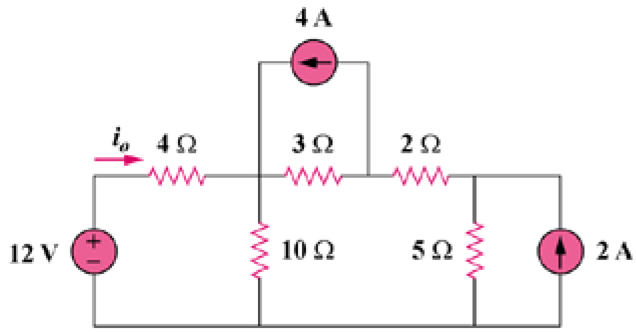
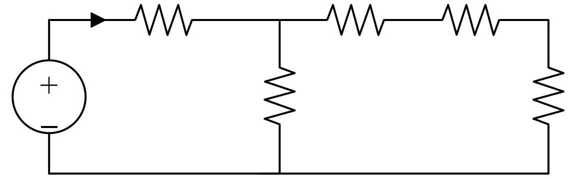


Figure 4.84

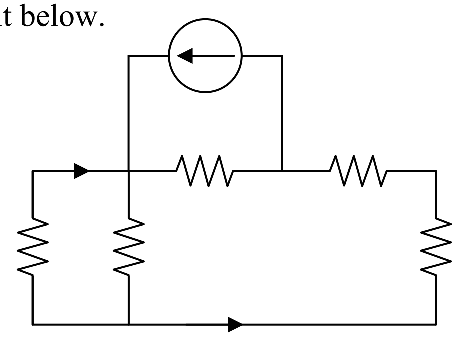
Chapter 4, Solution 16.

Let $i_o = i_{o1} + i_{o2} + i_{o3}$, where i_{o1}, i_{o2}, and i_{o3} are due to the 12-V, 4-A, and 2-A sources. For i_{o1}, consider the circuit below.



$$10||(3 + 2 + 5) = 5 \text{ ohms}, \quad i_{o1} = 12/(5 + 4) = (12/9) \text{ A}$$

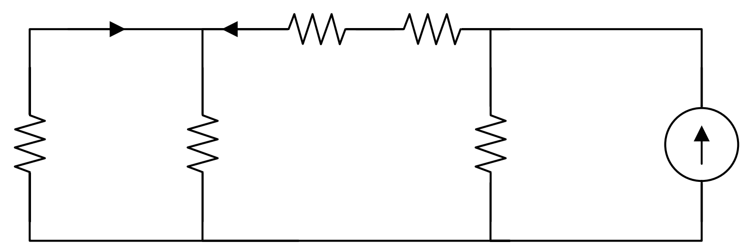
For i_{o2}, consider the circuit below.



$$2 + 5 + 4||10 = 7 + 40/14 = 69/7$$

$$i_1 = [3/(3 + 69/7)]4 = 84/90, \quad i_{o2} = [-10/(4 + 10)]i_1 = -6/9$$

For i_{o3}, consider the circuit below.



$$3 + 2 + 4||10 = 5 + 20/7 = 55/7$$

$$i_2 = [5/(5 + 55/7)]2 = 7/9, \quad i_{o3} = [-10/(10 + 4)]i_2 = -5/9$$

$$i_o = (12/9) - (6/9) - (5/9) = 1/9 = \underline{\textbf{111.11 mA}}$$

Chapter 4, Problem 17.

Use superposition to obtain v_x in the circuit of Fig. 4.85. Check your result using *PSpice.*

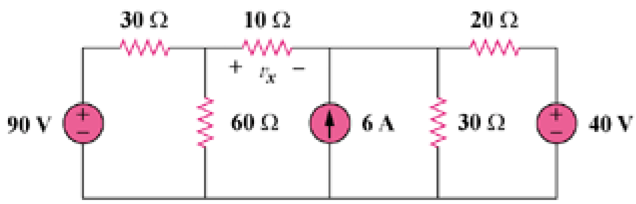
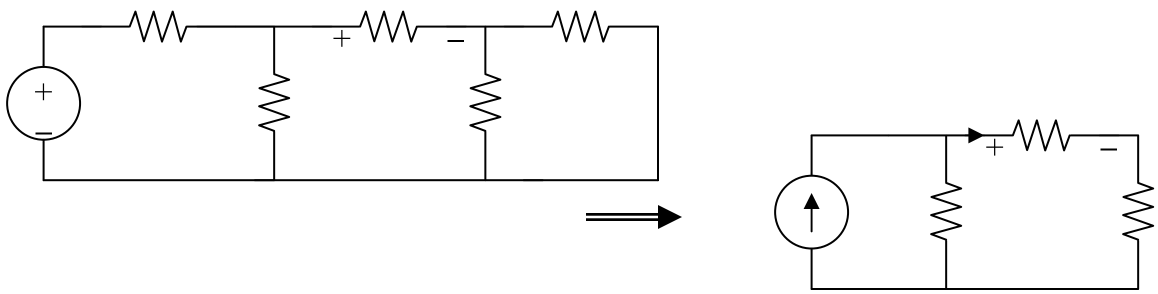


Figure 4.85

Chapter 4, Solution 17.

Let $v_x = v_{x1} + v_{x2} + v_{x3}$, where v_{x1}, v_{x2}, and v_{x3} are due to the 90-V, 6-A, and 40-V sources. For v_{x1}, consider the circuit below.

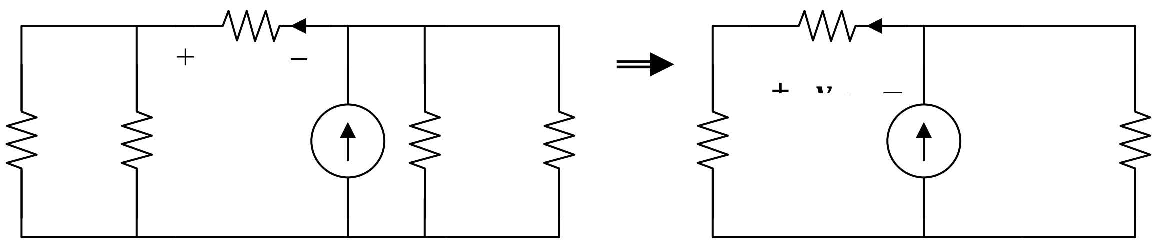


$$20||30 \;=\; 12 \text{ ohms},\;\; 60||30 \;=\; 20 \text{ ohms}$$

By using current division,

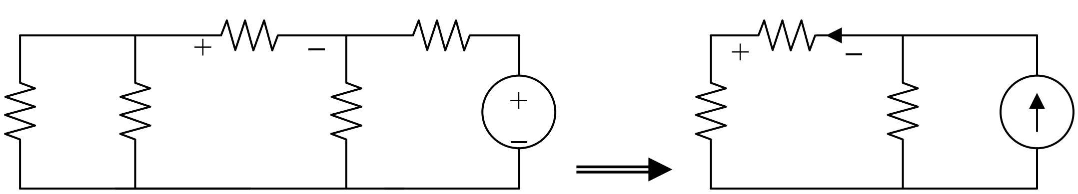
$$i_o \;=\; [20/(22 + 20)]3 \;=\; 60/42,\;\; v_{x1} \;=\; 10i_o \;=\; 600/42 \;=\; 14.286 \text{ V}$$

For v_{x2}, consider the circuit below.



$$i_o' \;=\; [12/(12 + 30)]6 \;=\; 72/42,\;\; v_{x2} \;=\; -10i_o' \;=\; -17.143 \text{ V}$$

For v_{x3}, consider the circuit below.



$$i_o'' \;=\; [12/(12 + 30)]2 \;=\; 24/42,\;\; v_{x3} \;=\; -10i_o'' \;=\; -5.714 = [12/(12 + 30)]2 \;=\; 24/42,\;\; v_{x3} \;=\; -10i_o'' \;=\; -5.714$$

$$= [12/(12 + 30)]2 \;=\; 24/42,\;\; v_{x3} \;=\; -10i_o'' \;=\; -5.714$$

$$v_x \;=\; 14.286 - 17.143 - 5.714 \;=\; \underline{\mathbf{-8.571\ V}}$$

Chapter 4, Problem 18.

Use superposition to find V_o in the circuit of Fig. 4.86.

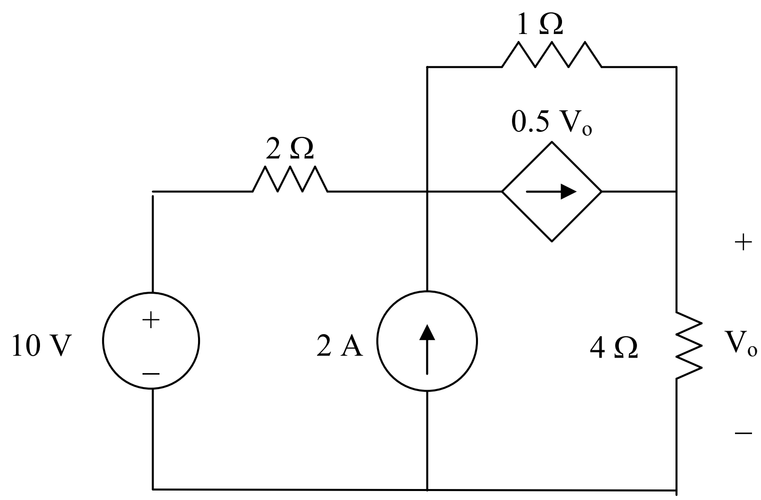
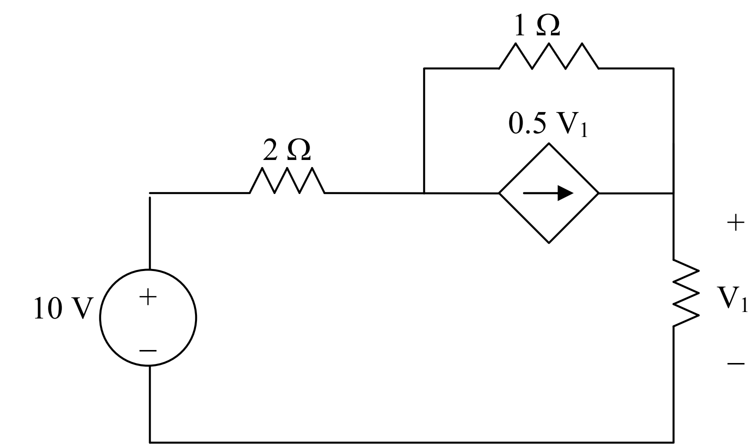
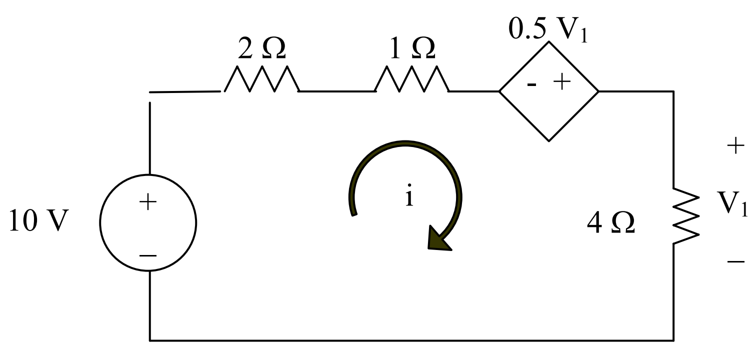


Figure 4.86 For Prob. 4.18.

Chapter 4, Solution 18.

Let $V_o = V_1 + V_2$, where V_1 and V_2 are due to 10-V and 2-A sources respectively. To find V_1, we use the circuit below.



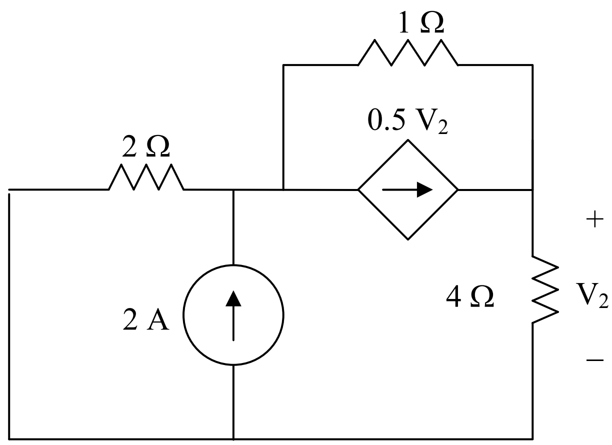


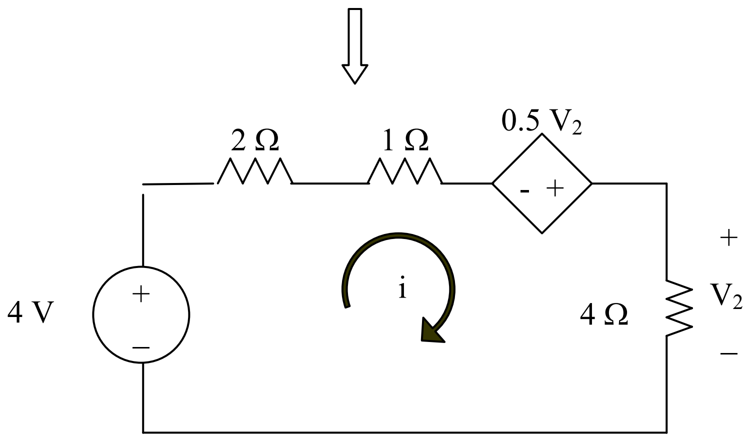
$$-10 + 7i - 0.5V_1 = 0$$

But $V_1 = 4i$

$$`10 = 7i - 2i = 5i \longrightarrow i = 2, \quad V_1 = 8 \text{ V}$$

To find V_2, we use the circuit below.





$- 4 + 7i – 0.5V_2 =0$

But $V_2 = 4i$

$4 = 7i - 2i = 5i \quad \longrightarrow \quad i = 0.8, \quad V_2 = 4i = 3.2$

$V_o = V_1 + V_2 = 8 + 3.2 =$ **$\underline{11.2\text{ V}}$**

Chapter 4, Problem 19.

Use superposition to solve for v_x in the circuit of Fig. 4.87.

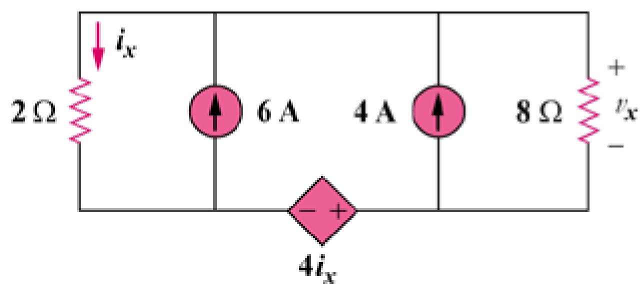
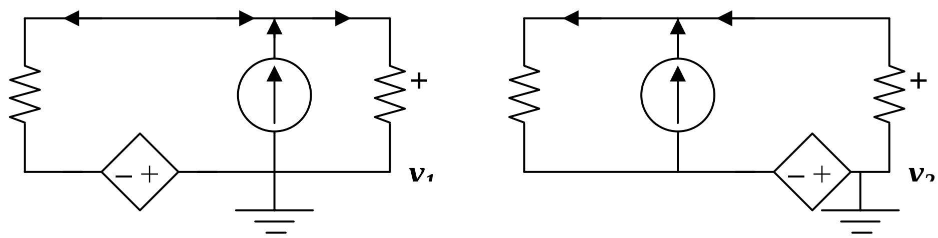


Figure 4.87

Chapter 4, Solution 19.

Let $v_x = v_1 + v_2$, where v_1 and v_2 are due to the 4-A and 6-A sources respectively.



To find v_1, consider the circuit in Fig. (a).

$$v_1/8 - 4 + (v_1 - (-4i_x))/2 = 0 \text{ or } (0.125+0.5)v_1 = 4 - 2i_x \text{ or } v_1 = 6.4 - 3.2i_x$$

But, $i_x = (v_1 - (-4i_x))/2$ or $i_x = -0.5v_1$. Thus,

$$v_1 = 6.4 + 3.2(0.5v_1), \text{ which leads to } v_1 = -6.4/0.6 = -10.667$$

To find v_2, consider the circuit shown in Fig. (b).

$$v_2/8 - 6 + (v_2 - (-4i_x))/2 = 0 \text{ or } v_2 + 3.2i_x = 9.6$$

But $i_x = -0.5v_2$. Therefore,

$$v_2 + 3.2(-0.5v_2) = 9.6 \text{ which leads to } v_2 = -16$$

Hence, $v_x = -10.667 - 16 = \underline{\mathbf{-26.67V}}$.

Checking,

$$i_x = -0.5v_x = 13.333\text{A}$$

Now all we need to do now is sum the currents flowing out of the top node.

$$13.333 - 6 - 4 + (-26.67)/8 = 3.333 - 3.333 = 0$$

Chapter 4, Problem 20.

Use source transformations to reduce the circuit in Fig. 4.88 to a single voltage source in series with a single resistor.

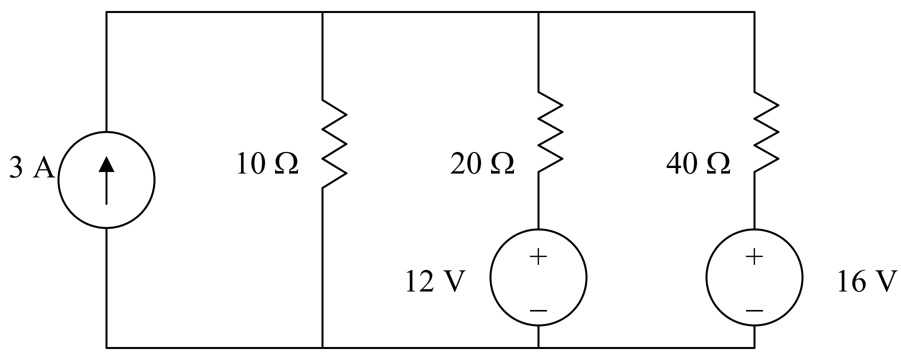
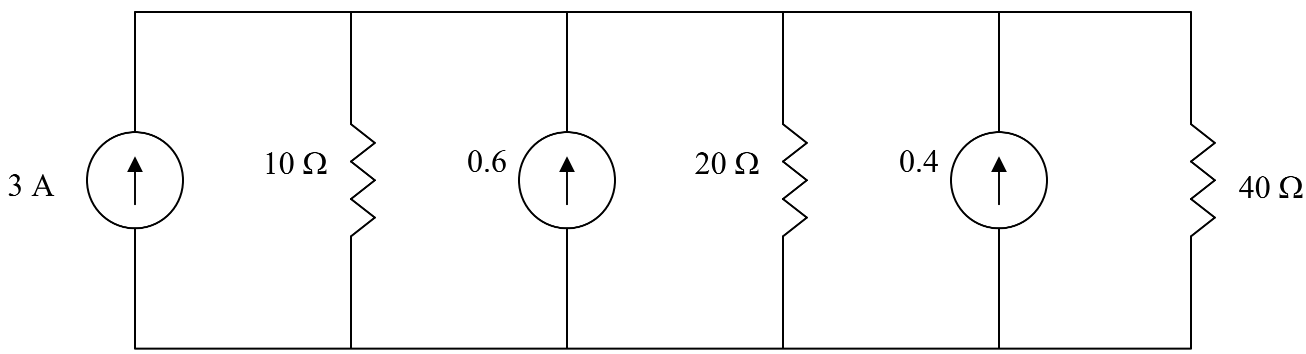


Figure 4.88 For Prob. 4.20.

Chapter 4, Solution 20.

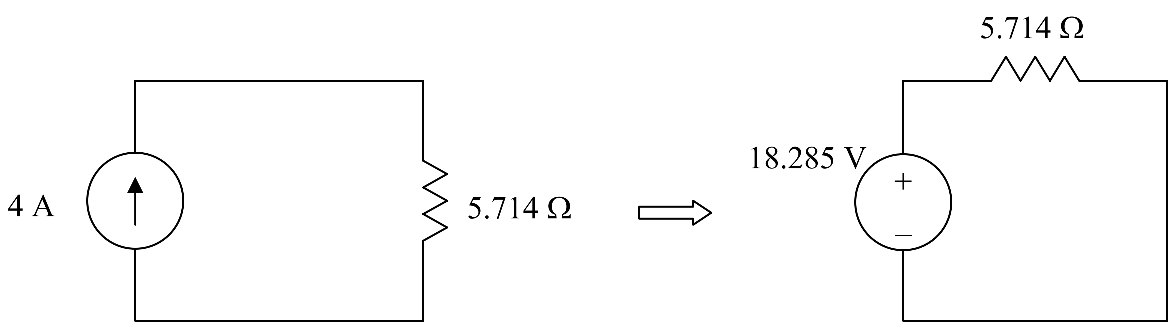
Convert the voltage sources to current sources and obtain the circuit shown below.



$$\frac{1}{R_{eq}} = \frac{1}{10} + \frac{1}{20} + \frac{1}{40} = 0.1 + 0.05 + 0.025 = 0.175 \longrightarrow R_{eq} = 5.714\ \Omega$$

$I_{eq} = 3 + 0.6 + 0.4 = 4$

Thus, the circuit is reduced as shown below. Please note, we that this is merely an exercise in combining sources and resistors. The circuit we have is an equivalent circuit which has no real purpose other than to demonstrate source transformation. In a practical situation, this would need some kind of reference and a use to an external circuit to be of real value.



Chapter 4, Problem 21.

Apply source transformation to determine v_o and i_o in the circuit in Fig. 4.89.

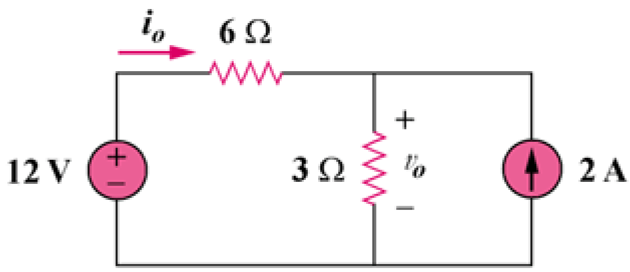
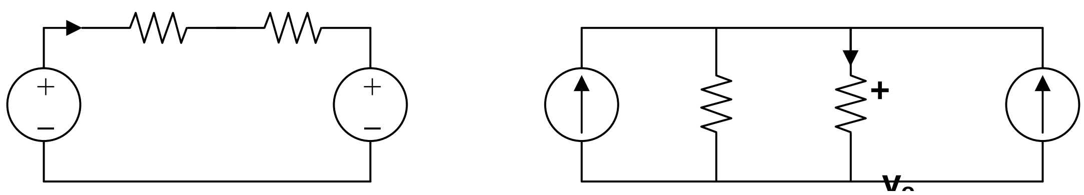


Figure 4.89

Chapter 4, Solution 21.

To get i_o, transform the current sources as shown in Fig. (a).



From Fig. (a), $-12 + 9i_o + 6 = 0$, therefore i_o = **666.7 mA**

To get v_o, transform the voltage sources as shown in Fig. (b).

$$i = [6/(3 + 6)](2 + 2) = 8/3$$

$$v_o = 3i = \mathbf{8\ V}$$

Chapter 4, Problem 22.

Referring to Fig. 4.90, use source transformation to determine the current and power in the 8-Ω resistor.

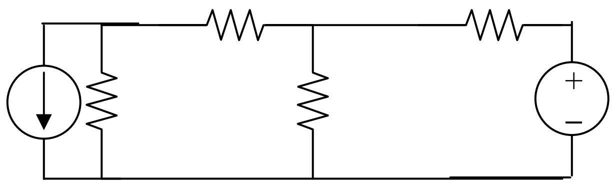
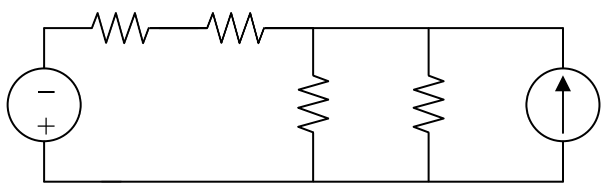
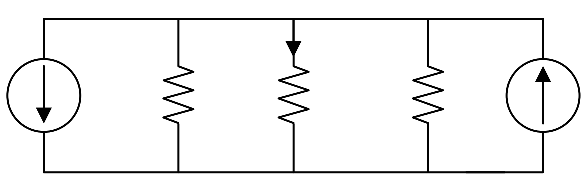


Figure 4.90

Chapter 4, Solution 22.

We transform the two sources to get the circuit shown in Fig. (a).





We now transform only the voltage source to obtain the circuit in Fig. (b).

10||10 = 5 ohms, i = [5/(5 + 4)](2 – 1) = 5/9 = **555.5 mA**

Chapter 4, Problem 23.

Referring to Fig. 4.91, use source transformation to determine the current and power in the 8-Ω resistor.

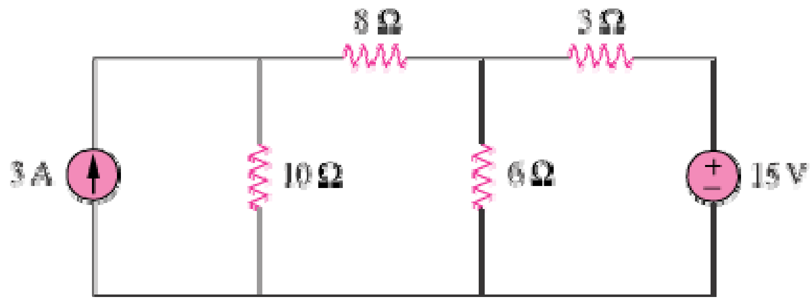
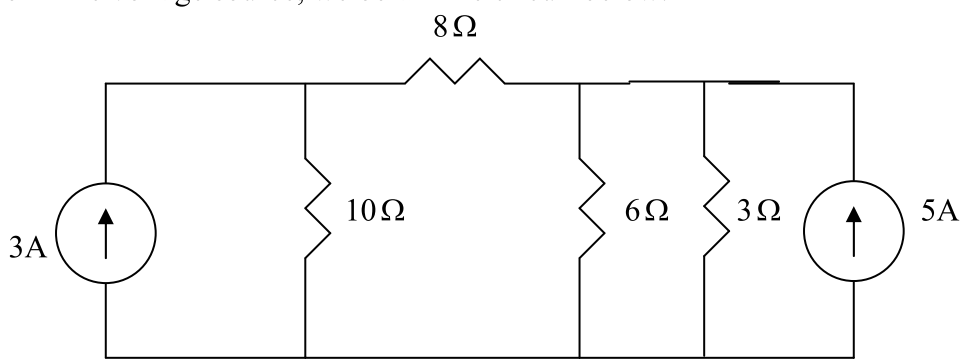


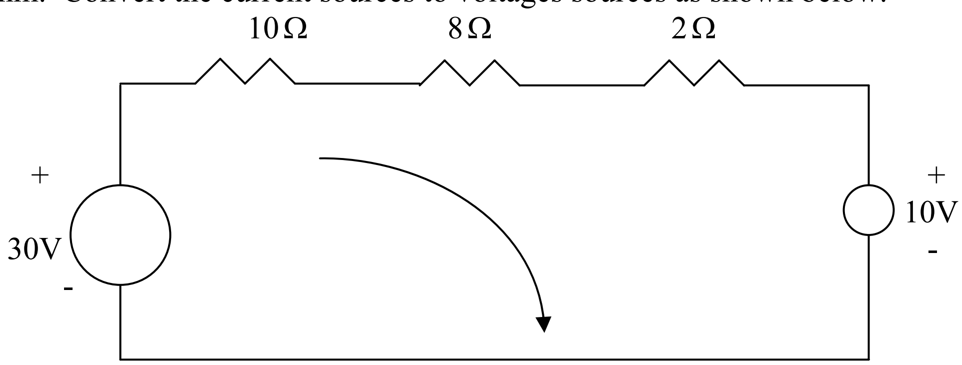
Figure 4.91

Chapter 4, Solution 23

If we transform the voltage source, we obtain the circuit below.



3//6 = 2-ohm. Convert the current sources to voltages sources as shown below.



Applying KVL to the loop gives

$-30+10+I(10+8+2)=0 \quad \longrightarrow \quad \underline{I=1\,\text{A}}$

$$p = VI = I^2 R = \underline{8\ \text{W}}$$

Chapter 4, Problem 24.

Use source transformation to find the voltage V_x in the circuit of Fig. 4.92.

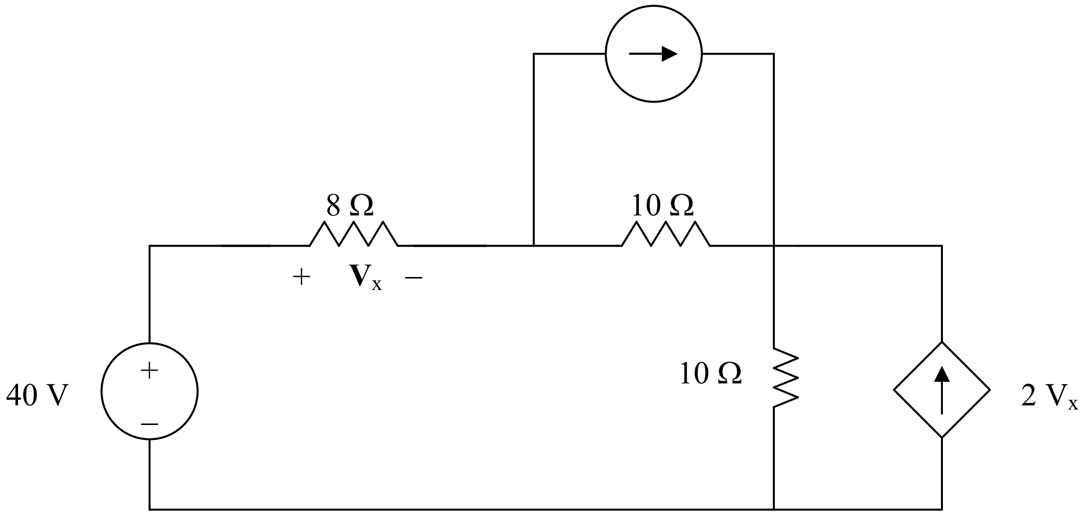


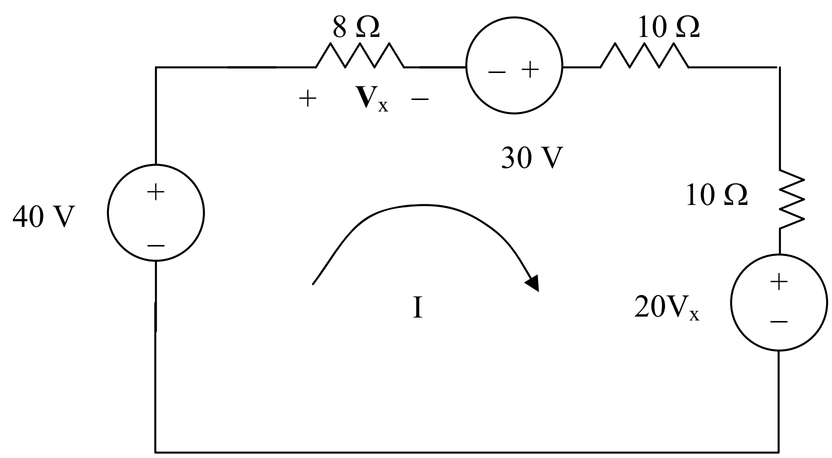
Figure 4.92 For Prob. 4.24.

Chapter 4, Solution 24.

Transform the two current sources in parallel with the resistors into their voltage source equivalents yield,

a 30-V source in series with a 10-Ω resistor and a $20V_x$-V sources in series with a 10-Ω resistor.

We now have the following circuit,



We now write the following mesh equation and constraint equation which will lead to a solution for V_x,

$28I - 70 + 20V_x = 0$ or $28I + 20V_x = 70$, but $V_x = 8I$ which leads to

$28I + 160I = 70$ or $I = 0.3723$ A or $V_x =$ **2.978 V**.

Chapter 4, Problem 25.

Obtain v_o in the circuit of Fig. 4.93 using source transformation. Check your result using *PSpice*.

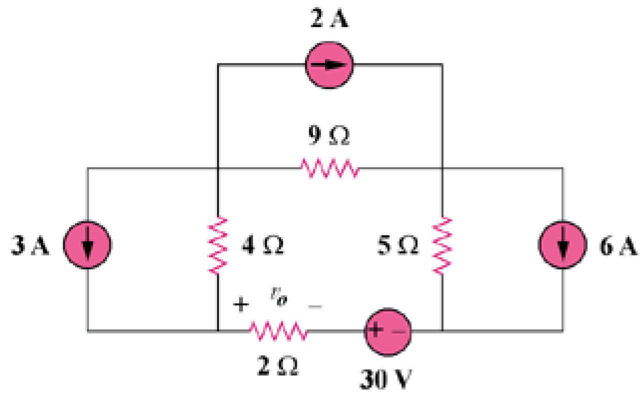
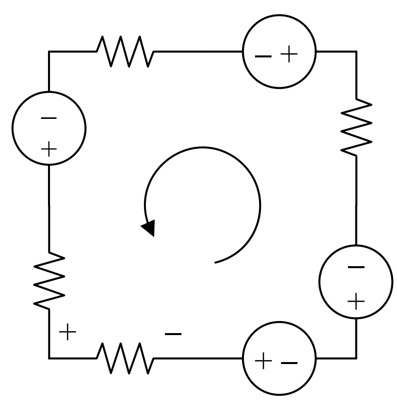


Figure 4.93

Chapter 4, Solution 25.

Transforming only the current source gives the circuit below.



Applying KVL to the loop gives,

$$-(4 + 9 + 5 + 2)i + 12 - 18 - 30 - 30 = 0$$

$$20i = -66 \text{ which leads to } i = -3.3$$

$v_o = 2i = \underline{\mathbf{-6.6\ V}}$

Chapter 4, Problem 26.

Use source transformation to find i_o in the circuit of Fig. 4.94.

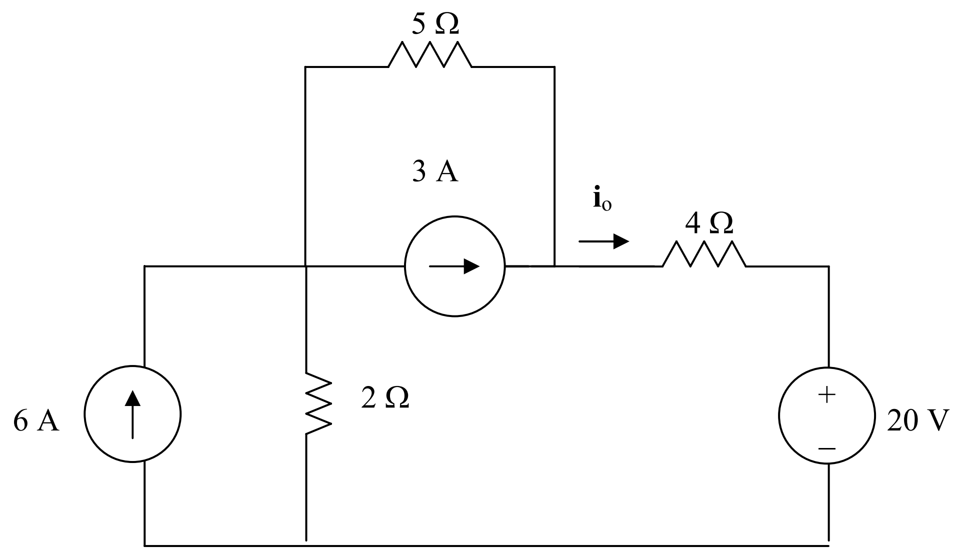
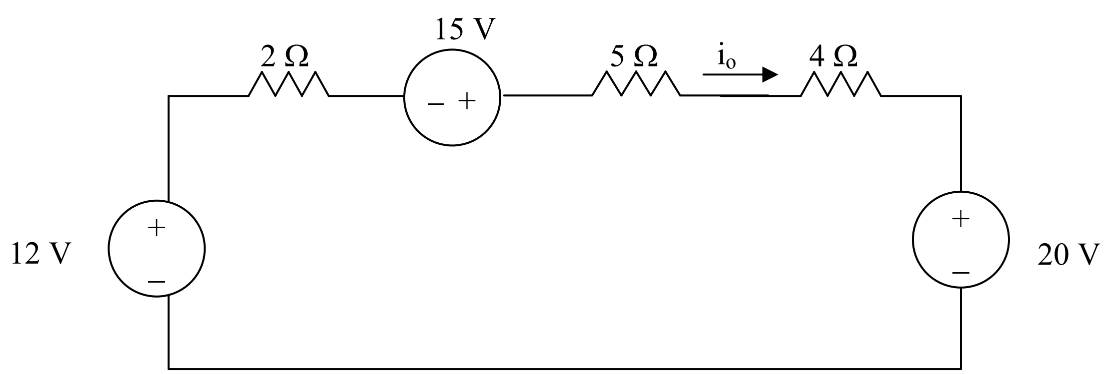


Figure 4.94 For Prob. 4.26.

Chapter 4, Solution 26.

Transforming the current sources gives the circuit below.



$-12 + 11i_o - 15 + 20 = 0$ or $11i_o = 7$ or $i_o =$ **636.4 mA**.

Chapter 4, Problem 27.

Apply source transformation to find v_x in the circuit of Fig. 4.95.

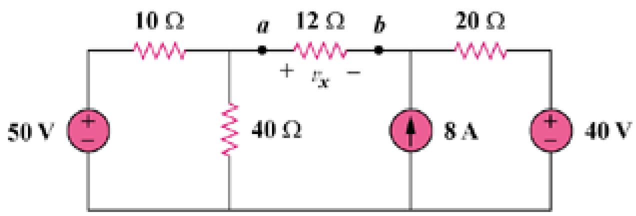


Figure 4.95

Chapter 4, Solution 27.

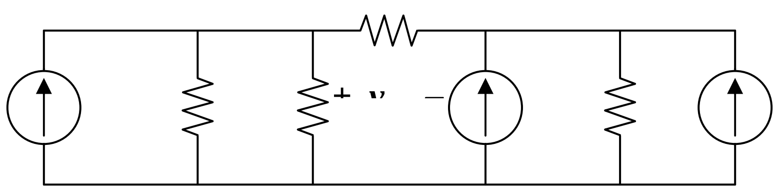
Transforming the voltage sources to current sources gives the circuit in Fig. (a).

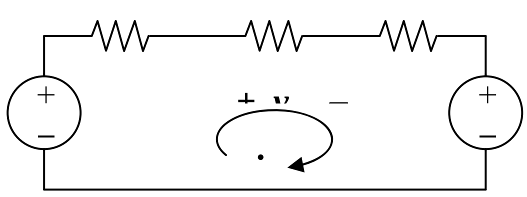
$$10||40 = 8 \text{ ohms}$$

Transforming the current sources to voltage sources yields the circuit in Fig. (b). Applying KVL to the loop,

$$-40 + (8 + 12 + 20)i + 200 = 0 \text{ leads to } i = -4$$

$$v_x \;\; 12i = \underline{\mathbf{-48\ V}}$$





Chapter 4, Problem 28.

Use source transformation to find I_o in Fig. 4.96.

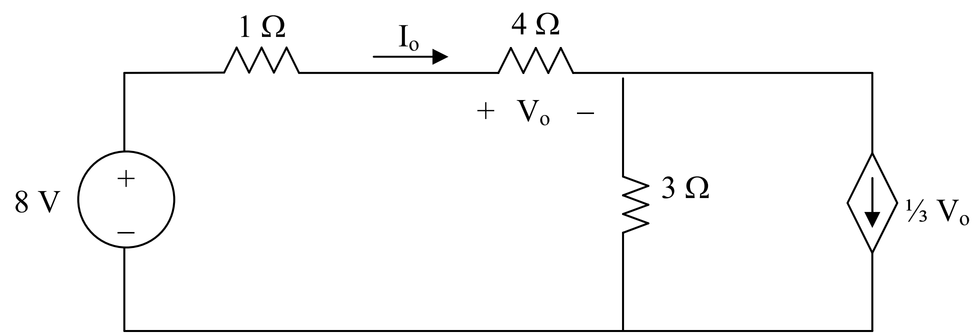
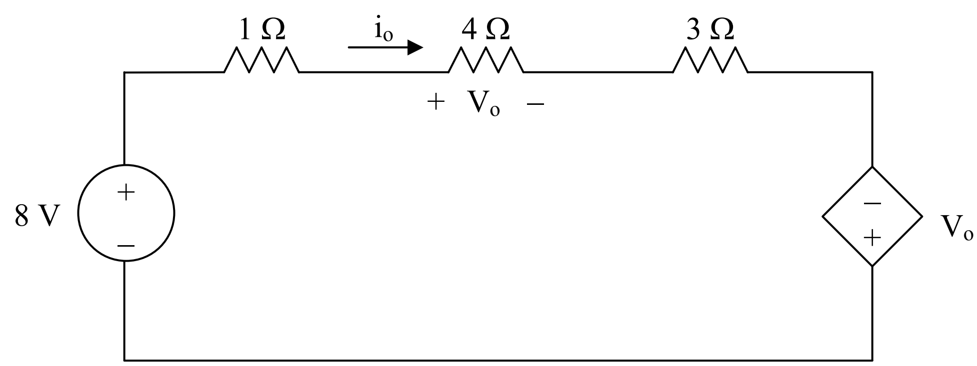


Figure 4.96 For Prob. 4.28.

Chapter 4, Solution 28.

Convert the dependent current source to a dependent voltage source as shown below.



Applying KVL,

$$-8 + i_o(1 + 4 + 3) - V_o = 0$$

But $V_o = 4i_o$

$$-8 + 8i_o - 4i_o = 0 \longrightarrow i_o = \underline{2\ \text{A}}$$

Chapter 4, Problem 29.

Use source transformation to find $\boldsymbol{v_o}$ in the circuit of Fig. 4.93.

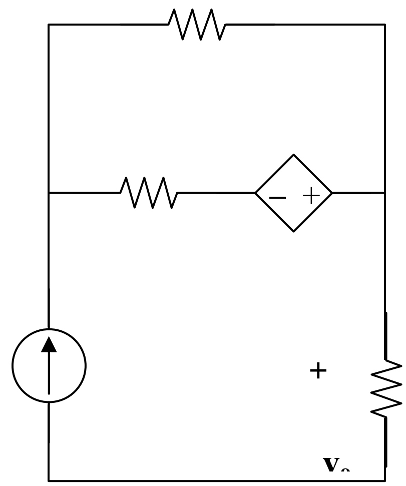
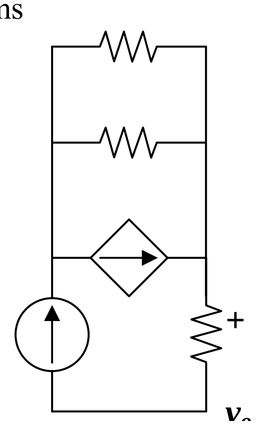
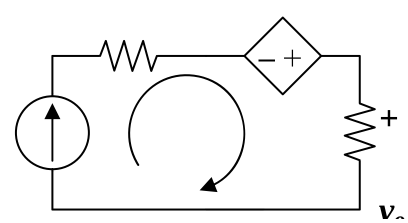


Figure 4.93

Chapter 4, Solution 29.

Transform the dependent voltage source to a current source as shown in Fig. (a). 2||4 = (4/3) k ohms





It is clear that i = 3 mA which leads to v_o = 1000i = **<u>3 V</u>**

If the use of source transformations was not required for this problem, the actual answer could have been determined by inspection right away since the only current that could have flowed through the 1 k ohm resistor is 3 mA.

Chapter 4, Problem 30.

Use source transformation on the circuit shown in Fig 4.98 to find i_x.

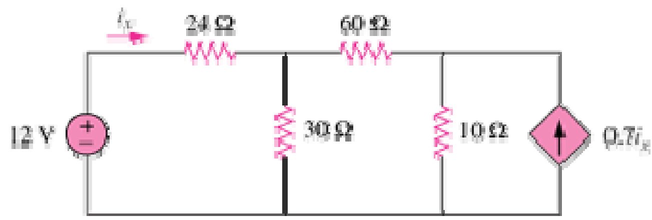
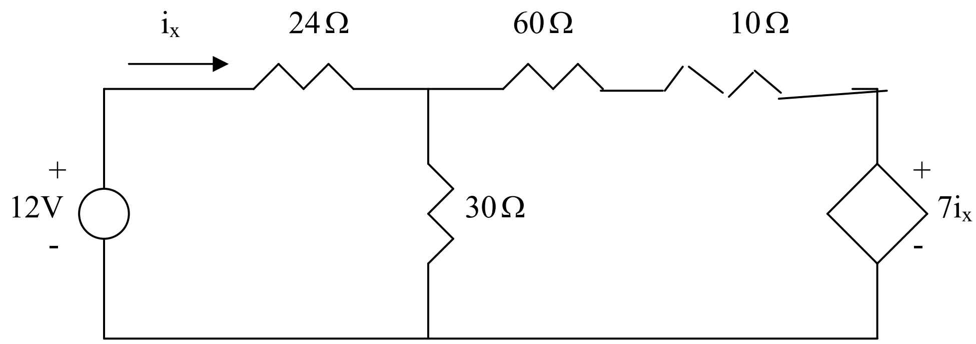


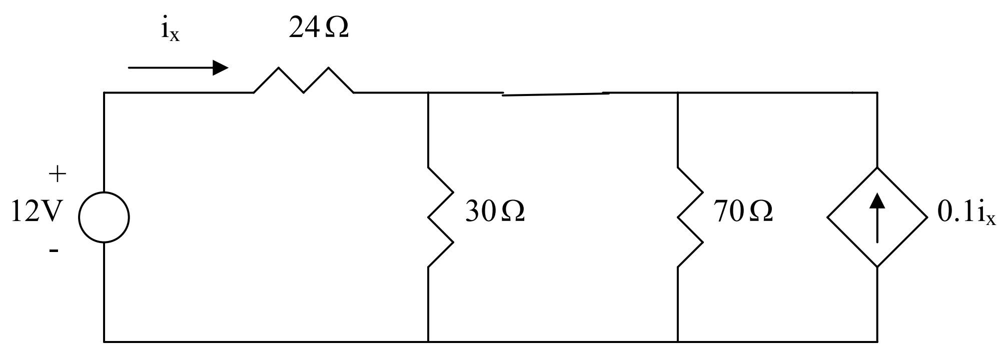
Figure 4.98

Chapter 4, Solution 30

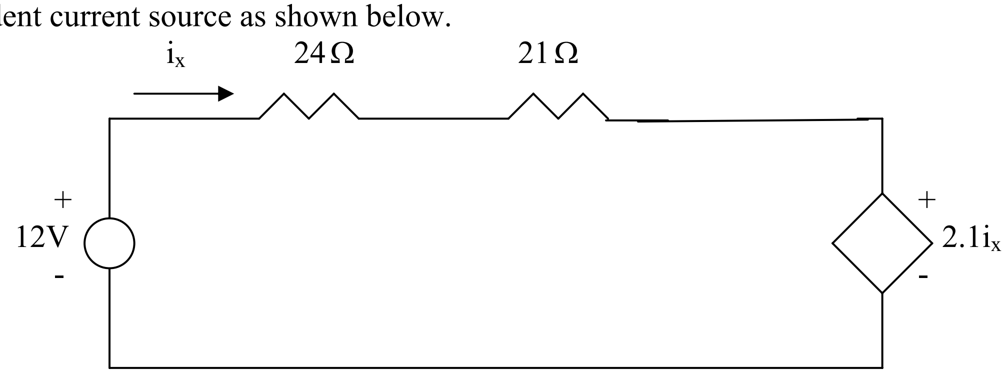
Transform the dependent current source as shown below.



Combine the 60-ohm with the 10-ohm and transform the dependent source as shown below.



Combining 30-ohm and 70-ohm gives 30//70 = 70x30/100 = 21-ohm. Transform the dependent current source as shown below.



Applying KVL to the loop gives

$$45i_x - 12 + 2.1i_x = 0 \quad \longrightarrow \quad i_x = \frac{12}{47.1} = \underline{254.8\,\text{mA}}$$

Chapter 4, Problem 31.
Determine v_x in the circuit of Fig. 4.99 using source transformation.

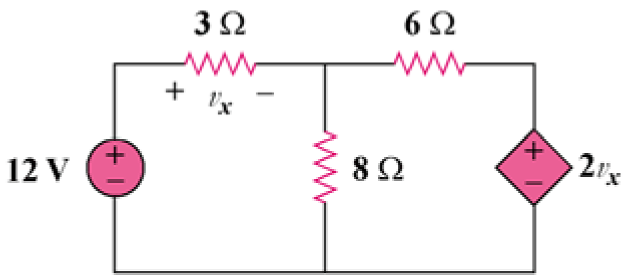
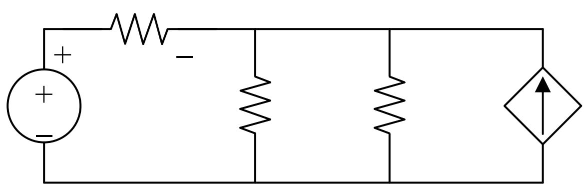
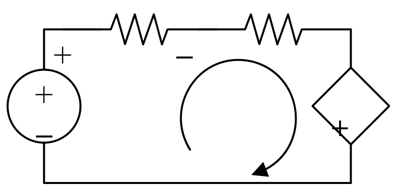


Figure 4.99

Chapter 4, Solution 31.
Transform the dependent source so that we have the circuit in
Fig. (a). 6||8 = (24/7) ohms. Transform the dependent source again to get the circuit in
Fig. (b).





From Fig. (b),

$$v_x = 3i, \text{ or } i = v_x/3.$$

Applying KVL,

$$-12 + (3 + 24/7)i + (24/21)v_x = 0$$

$$12 = [(21 + 24)/7]v_x/3 + (8/7)v_x, \text{ leads to } v_x = 84/23 = \underline{\mathbf{3.652\ V}}$$

Chapter 4, Problem 32.

Use source transformation to find $\boldsymbol{i_x}$ in the circuit of Fig. 4.100.

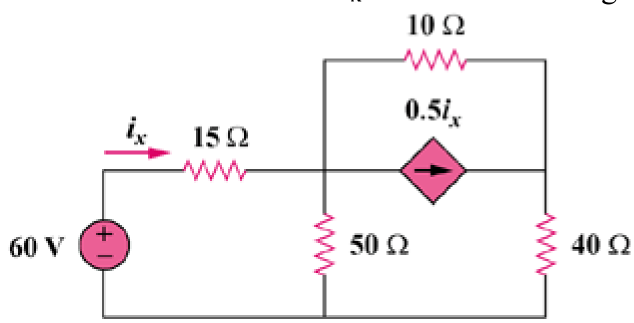
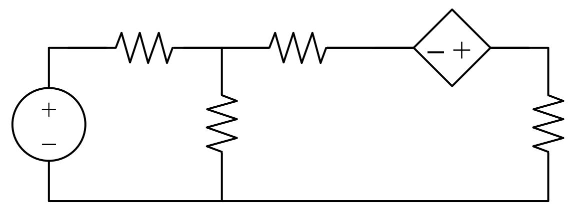
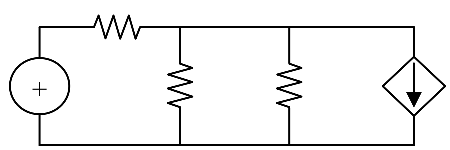


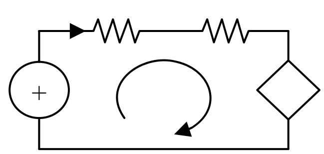
Figure 4.100

Chapter 4, Solution 32.

As shown in Fig. (a), we transform the dependent current source to a voltage source,







In Fig. (b), 50||50 = 25 ohms. Applying KVL in Fig. (c),

$-60 + 40i_x - 2.5i_x = 0$, or i_x = **<u>1.6 A</u>**

Chapter 4, Problem 33.

Determine $\boldsymbol{R}_{\mathrm{Th}}$ and $\boldsymbol{V}_{\mathrm{Th}}$ at terminals 1-2 of each of the circuits of Fig. 4.101.

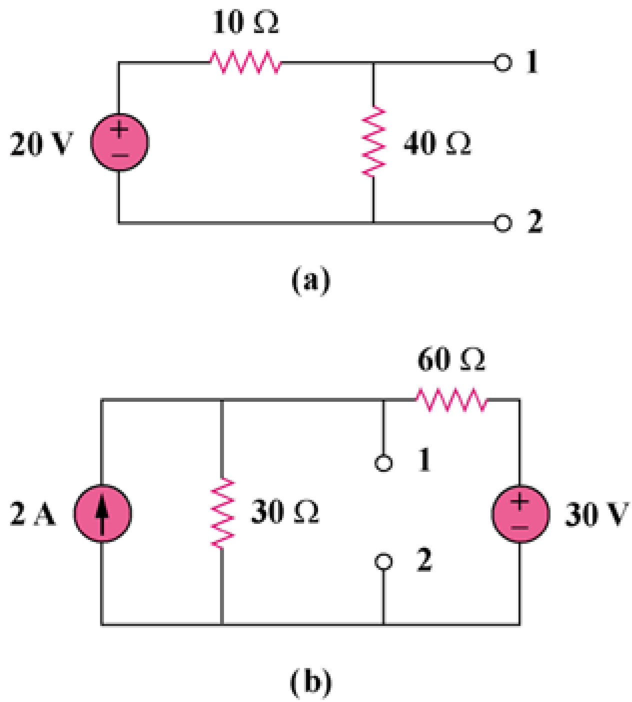


Figure 4.101

Chapter 4, Solution 33.

(a) $\quad R_{Th} = 10||40 = 400/50 = \underline{\mathbf{8\ ohms}}$

$$V_{Th} = (40/(40 + 10))20 = \underline{\mathbf{16\ V}}$$

(b) $\quad R_{Th} = 30||60 = 1800/90 = \underline{\mathbf{20\ ohms}}$

$$2 + (30 - v1)/60 = v_1/30, \text{ and } v_1 = V_{Th}$$

$$120 + 30 - v_1 = 2v_1, \text{ or } v_1 = 50\ V$$

$$V_{Th} = \underline{\mathbf{50\ V}}$$

Chapter 4, Problem 34.

Find the Thevenin equivalent at terminals ***a-b*** of the circuit in Fig. 4.102.

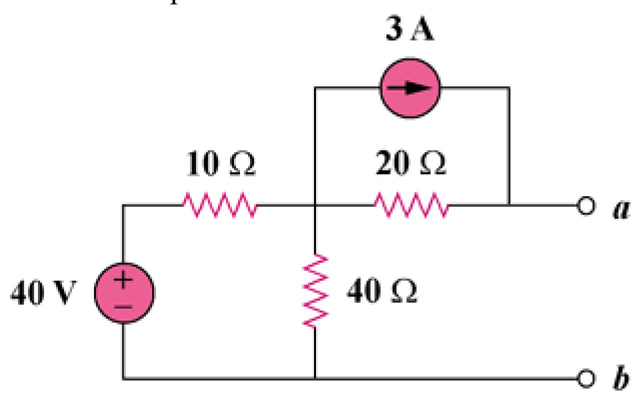
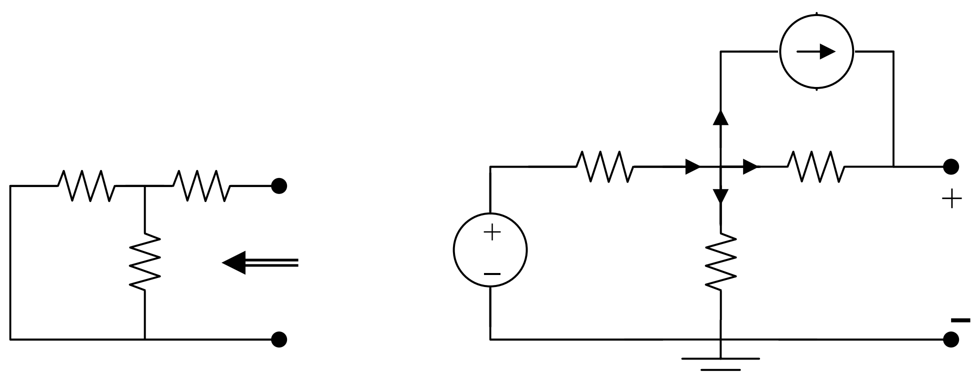


Figure 4.102

Chapter 4, Solution 34.

To find R_{Th}, consider the circuit in Fig. (a).



$$R_{Th} = 20 + 10||40 = 20 + 400/50 = \underline{\textbf{28 ohms}}$$

To find V_{Th}, consider the circuit in Fig. (b).

At node 1, $(40 - v_1)/10 = 3 + [(v_1 - v_2)/20] + v_1/40,\ 40 = 7v_1 - 2v_2$ (1)

At node 2, $3 + (v1 - v2)/20 = 0$, or $v1 = v2 - 60$ (2)

Solving (1) and (2), $v_1 = 32$ V, $v_2 = 92$ V, and $V_{Th} = v_2 = \underline{\textbf{92 V}}$

Chapter 4, Problem 35.

Use Thevenin's theorem to find v_o in Prob. 4.12.

Chapter 4, Problem 12**.**
Determine v_o in the circuit in Fig. 4.80 using the superposition principle.

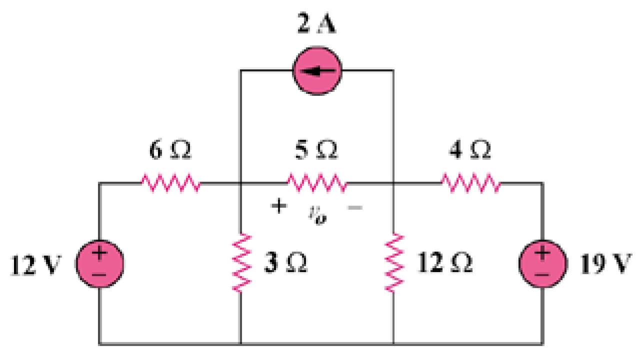


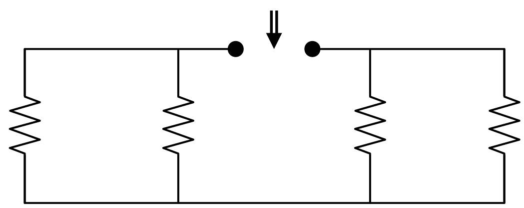
Figure 4.80

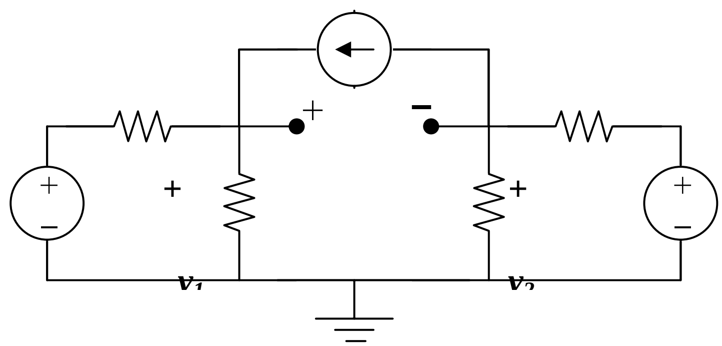
Chapter 4, Solution 35.

To find R_{Th}, consider the circuit in Fig. (a).

$$R_{Th} = R_{ab} = 6||3 + 12||4 = 2 + 3 = 5 \text{ ohms}$$

To find V_{Th}, consider the circuit shown in Fig. (b).

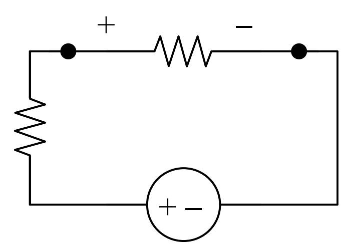




At node 1, $\quad 2 + (12 - v_1)/6 = v_1/3, \text{ or } v_1 = 8$

At node 2, $\quad (19 - v_2)/4 = 2 + v_2/12, \text{ or } v_2 = 33/4$

But, $\quad -v_1 + V_{Th} + v_2 = 0, \text{ or } V_{Th} = v_1 - v_2 = 8 - 33/4 = -0.25$



$$v_o = V_{Th}/2 = -0.25/2 = \underline{\mathbf{-125\ mV}}$$

Chapter 4, Problem 36.
Solve for the current ***i*** in the circuit of Fig. 4.103 using Thevenin's theorem. (*Hint:* Find the Thevenin equivalent as seen by the 12-Ω resistor.)

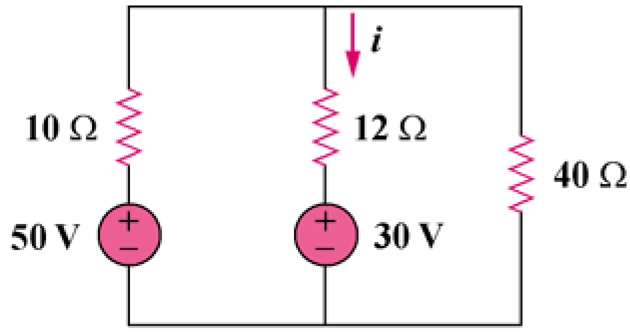
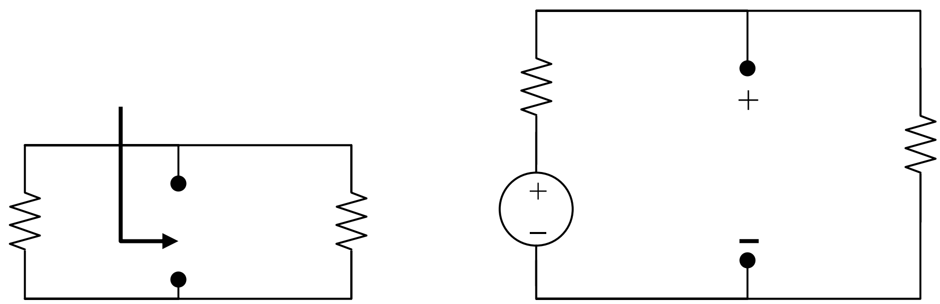


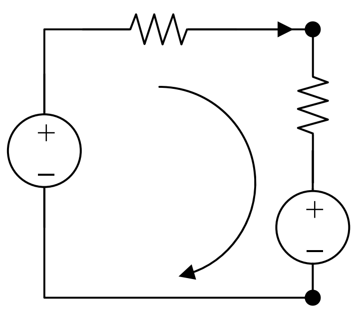
Figure 4.103

Chapter 4, Solution 36.
Remove the 30-V voltage source and the 20-ohm resistor.



From Fig. (a), $R_{Th} = 10||40 = 8$ ohms

From Fig. (b), $V_{Th} = (40/(10 + 40))50 = 40V$



The equivalent circuit of the original circuit is shown in Fig. (c). Applying KVL,

$$30 - 40 + (8 + 12)i = 0, \text{ which leads to } i = \underline{\mathbf{500mA}}$$

Chapter 4, Problem 37.

Find the Norton equivalent with respect to terminals *a-b* in the circuit shown in Fig. 4.100.

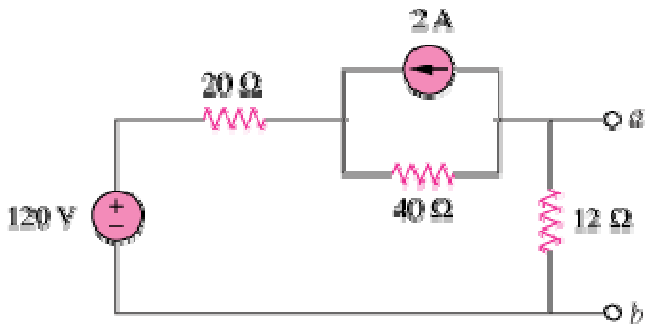
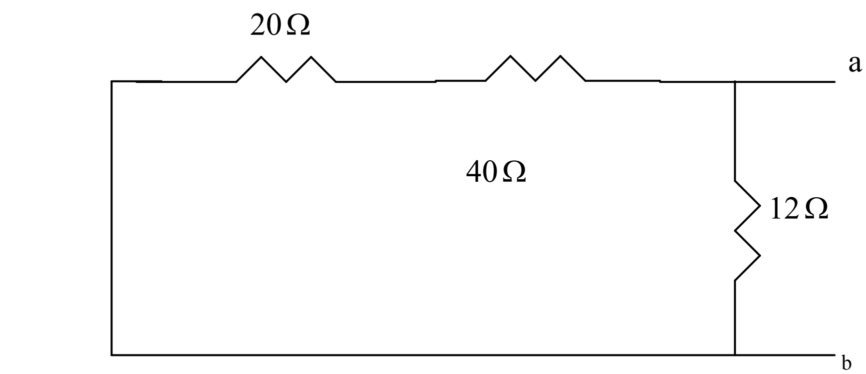


Figure 4.100

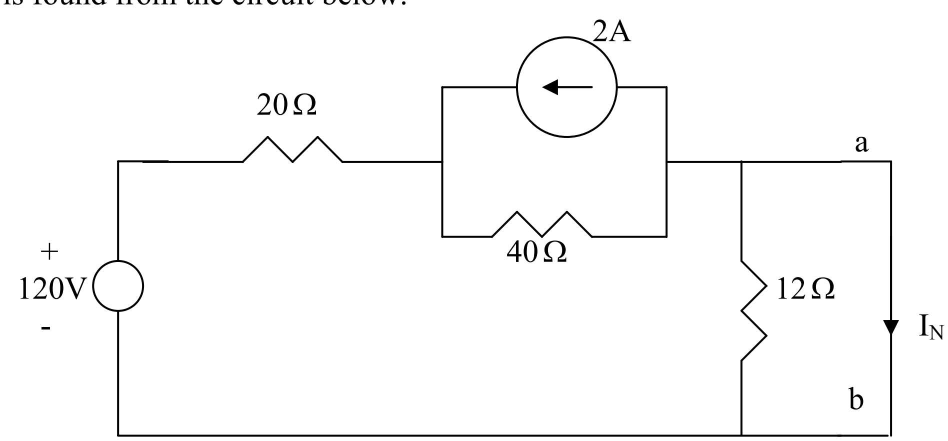
Chapter 4, Solution 37

R_N is found from the circuit below.

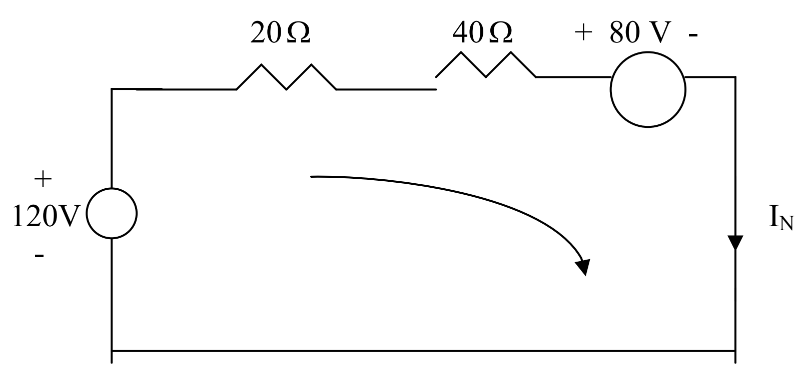


$R_N = 12//(20+40) = \underline{10\Omega}$

I_N is found from the circuit below.



Applying source transformation to the current source yields the circuit below.



Applying KVL to the loop yields

$$-120 + 80 + 60I_N = 0 \quad \longrightarrow \quad I_N = 40/60 = \underline{\mathbf{666.7\ mA}}.$$

Chapter 4, Problem 38.

Apply Thèvenin's theorem to find V_o in the circuit of Fig. 4.105.

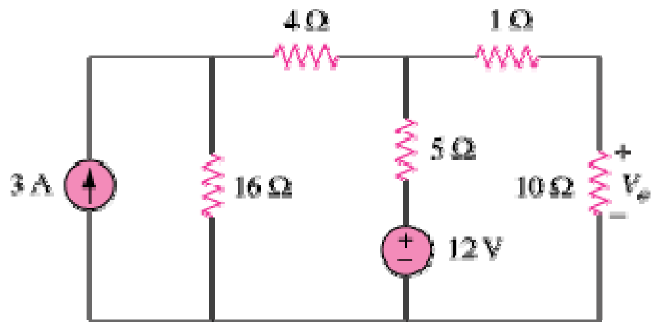
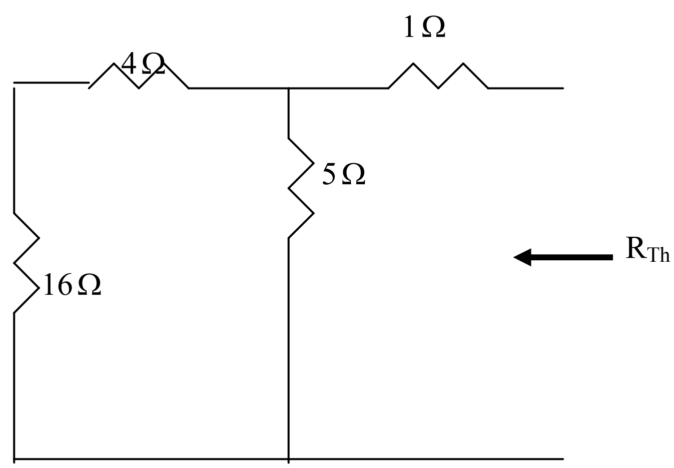


Figure 4.105

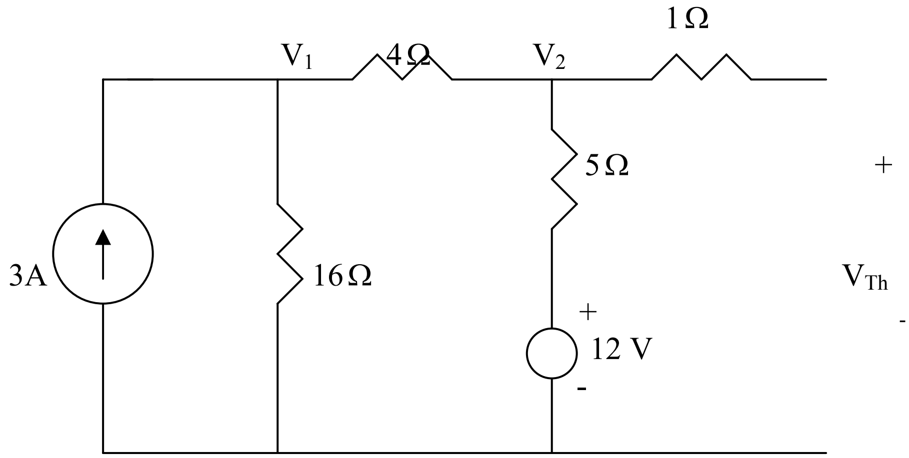
Chapter 4, Solution 38

We find Thevenin equivalent at the terminals of the 10-ohm resistor. For R_{Th}, consider the circuit below.



$$R_{Th} = 1 + 5//(4+16) = 1 + 4 = 5\Omega$$

For V_{Th}, consider the circuit below.



At node 1,

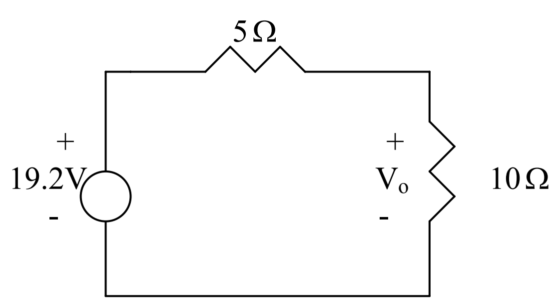
$$3 = \frac{V_1}{16} + \frac{V_1 - V_2}{4} \longrightarrow 48 = 5V_1 - 4V_2 \qquad (1)$$

At node 2,

$$\frac{V_1 - V_2}{4} + \frac{12 - V_2}{5} = 0 \longrightarrow 48 = -5V_1 + 9V_2 \qquad (2)$$

Solving (1) and (2) leads to
$V_{Th} = V_2 = 19.2$

Thus, the given circuit can be replaced as shown below.



Using voltage division,

$$V_o = \frac{10}{10+5}(19.2) = 12.8 \text{ V}$$

Chapter 4, Problem 39.

Obtain the Thevenin equivalent at terminals a-b of the circuit in Fig. 4.106.

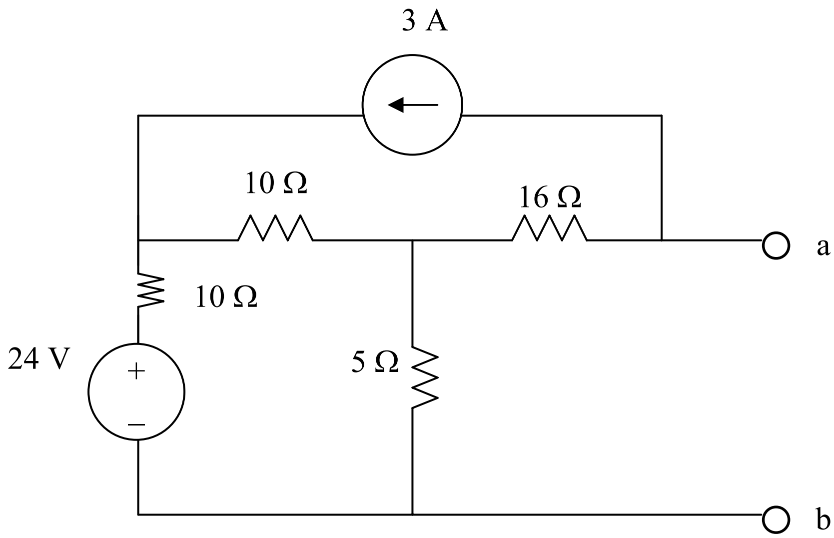
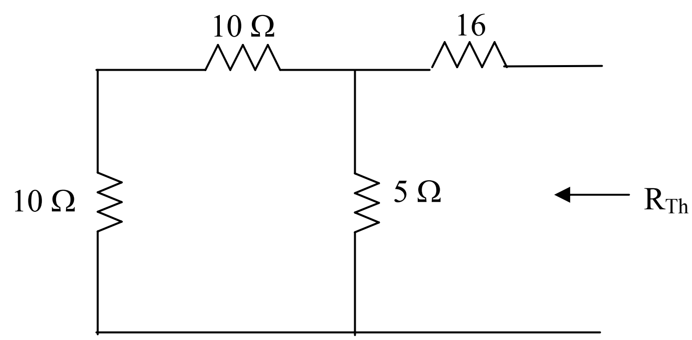


Figure 4.106 For Prob. 4.39.

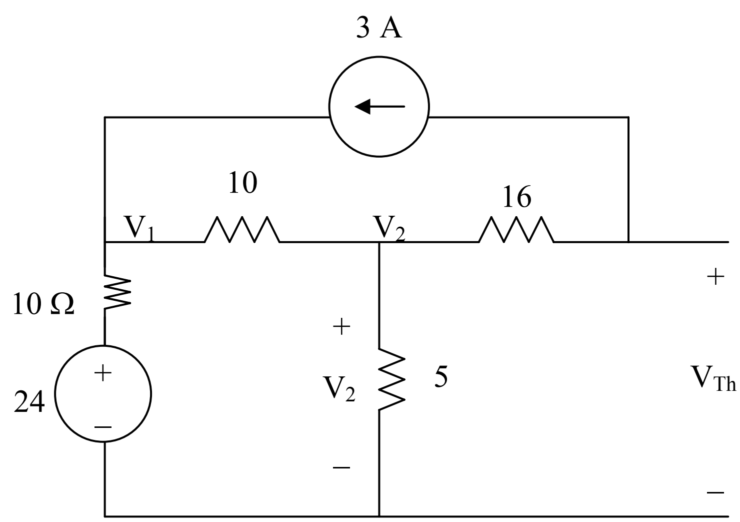
Chapter 4, Solution 39.

We obtain R_{Th} using the circuit below.



$$R_{Th} = 16 + 20 // 5 = 16 + \frac{20x5}{25} = \underline{20\ \ \Omega}$$

To find V_{Th}, we use the circuit below.



At node 1,

$$\frac{24 - V_1}{10} + 3 = \frac{V_1 - V_2}{10} \longrightarrow 54 = 2V_1 - V_2 \qquad (1)$$

At node 2,

$$\frac{V_1 - V_2}{10} = 3 + \frac{V_2}{5} \longrightarrow 60 = 2V_1 - 6V_2 \qquad (2)$$

Substracting (1) from (2) gives

$$6 = -5V_1 \longrightarrow V_2 = 1.2 \text{ V}$$

But

$$-V_2 + 16x3 + V_{Th} = 0 \longrightarrow V_{Th} = \underline{-49.2 \text{ V}}$$

Chapter 4, Problem 40.

Find the Thevenin equivalent at terminals a-b of the circuit in Fig. 4.107.

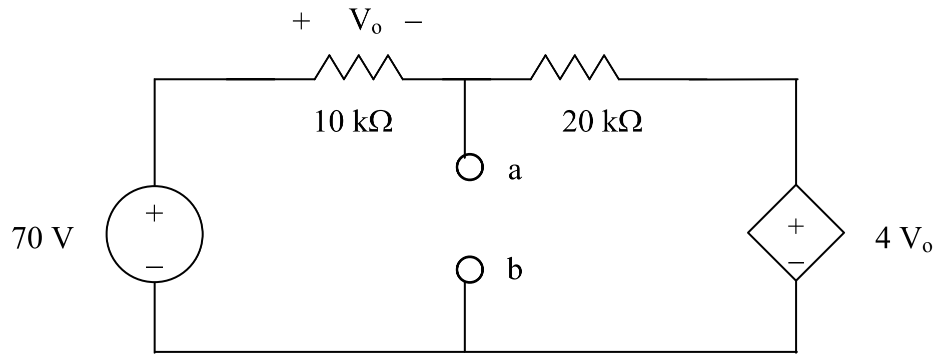


Figure 4.107 For Prob. 4.40.

Chapter 4, Solution 40.

To obtain V_{Th}, we apply KVL to the loop.

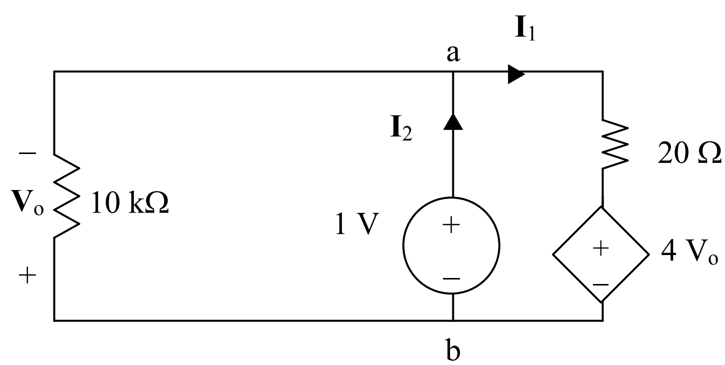
$$-70+(10+20)kI+4V_o=0$$

But $V_o=10kI$

$$70=70kI \longrightarrow I=1mA$$

$$-70+10kI+V_{Th}=0 \longrightarrow V_{Th}=\underline{60\text{ V}}$$

To find R_{Th}, we remove the 70-V source and apply a 1-V source at terminals a-b, as shown in the circuit below.



We notice that $V_o = -1$ V.

$$-1+20kI_1+4V_o=0 \longrightarrow I_1=0.25\text{ mA}$$

$$I_2=I_1+\frac{1V}{10k}=0.35\text{ mA}$$

$$R_{Th}=\frac{1V}{I_2}=\frac{1}{0.35}k\Omega=\underline{2.857\text{ k}\Omega}$$

Chapter 4, Problem 41.

Find the Thèvenin and Norton equivalents at terminals *a*-*b* of the circuit shown in Fig. 4.108.

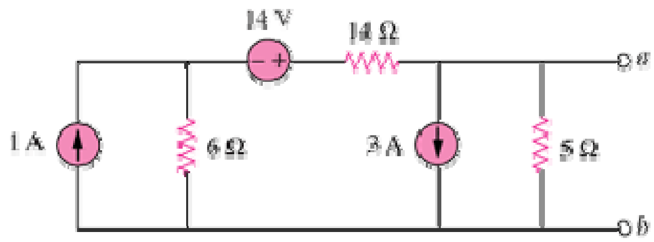
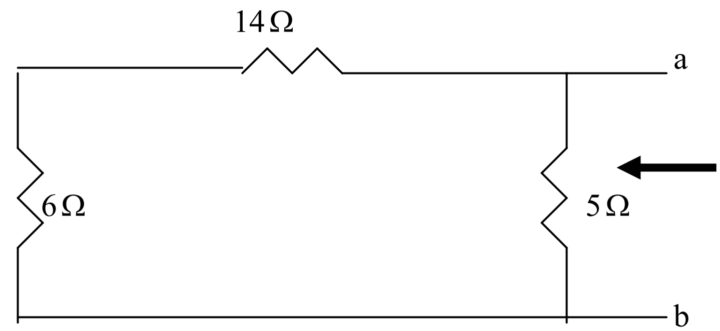


Figure 4.108

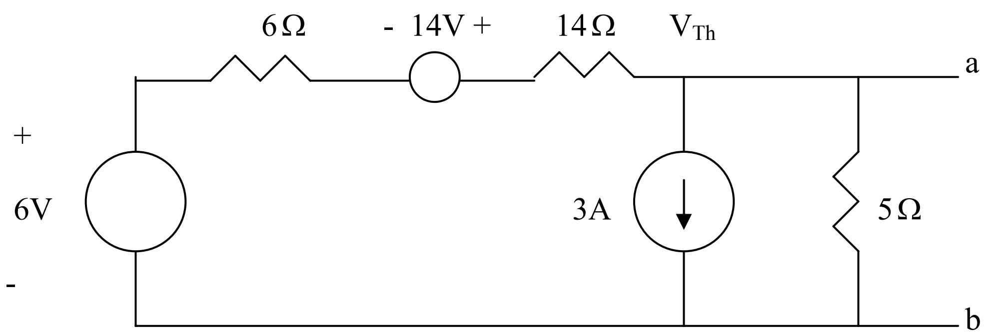
Chapter 4, Solution 41

To find R_{Th}, consider the circuit below



$$R_{Th} = 5//(14+6) = 4\Omega = R_N$$

Applying source transformation to the 1-A current source, we obtain the circuit below.



At node a,

$$\frac{14+6-V_{Th}}{6+14} = 3 + \frac{V_{Th}}{5} \quad \longrightarrow \quad V_{Th} = -8\text{ V}$$

$$I_N = \frac{V_{Th}}{R_{Th}} = (-8)/4 = -2\text{ A}$$

Thus,

$$\underline{R_{Th} = R_N = 4\Omega, \quad V_{Th} = -8\text{V}, \quad I_N = -2\text{ A}}$$

Chapter 4, Problem 42.

For the circuit in Fig. 4.109, find Thevenin equivalent between terminals ***a*** and ***b***.

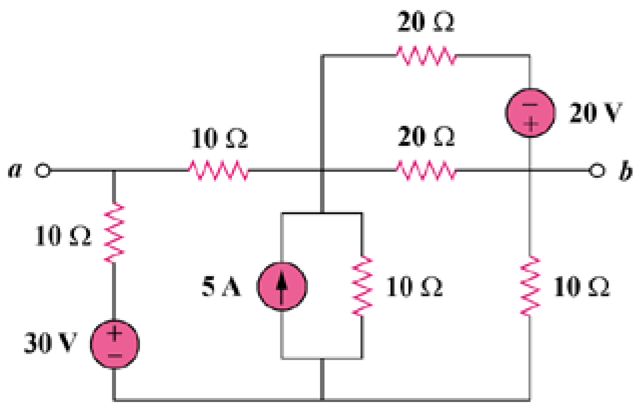
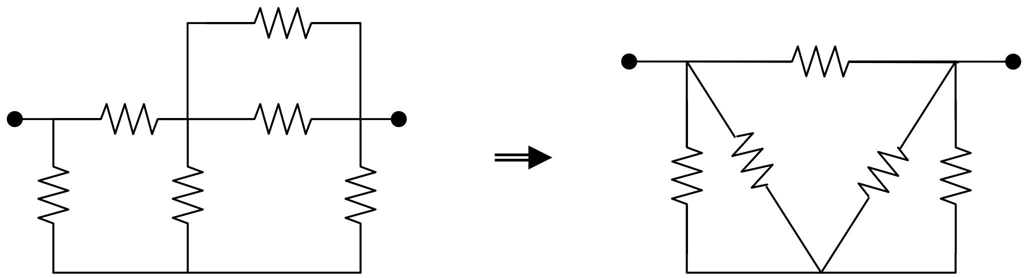


Figure 4.109

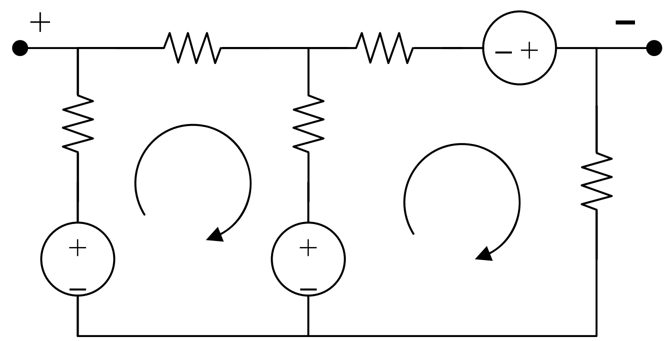
Chapter 4, Solution 42.

To find R_{Th}, consider the circuit in Fig. (a).



$20||20 = 10$ ohms. Transform the wye sub-network to a delta as shown in Fig. (b). $10||30 = 7.5$ ohms. $R_{Th} = R_{ab} = 30||(7.5 + 7.5) =$ **<u>10 ohms</u>**.

To find V_{Th}, we transform the 20-V and the 5-V sources. We obtain the circuit shown in Fig. (c).



For loop 1, $\quad -30 + 50 + 30i_1 - 10i_2 = 0$, or $-2 = 3i_1 - i_2 \qquad (1)$

For loop 2, $\quad -50 - 10 + 30i_2 - 10i_1 = 0$, or $6 = -i_1 + 3i_2 \qquad (2)$

Solving (1) and (2), $\quad i_1 = 0,\ i_2 = 2$ A

Applying KVL to the output loop, $-v_{ab} - 10i_1 + 30 - 10i_2 = 0$, $v_{ab} = 10$ V

$V_{Th} = v_{ab} =$ **<u>10 volts</u>**

Chapter 4, Problem 43.

Find the Thevenin equivalent looking into terminals ***a-b*** of the circuit in Fig. 4.110 and solve for i_x.

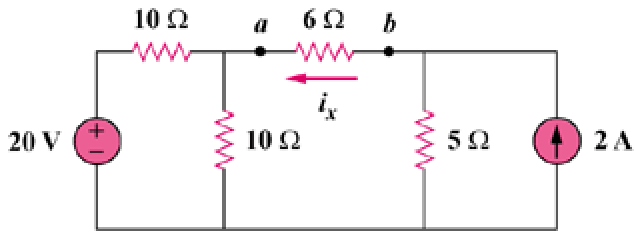
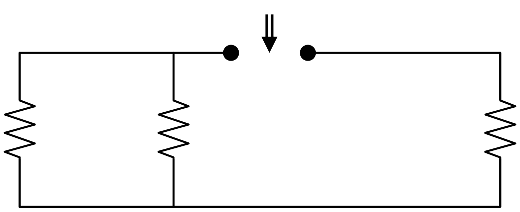
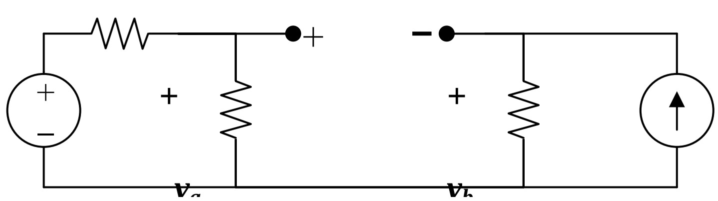


Figure 4.110

Chapter 4, Solution 43.

To find R_{Th}, consider the circuit in Fig. (a).





$$R_{Th} = 10||10 + 5 = \underline{\textbf{10 ohms}}$$

To find V_{Th}, consider the circuit in Fig. (b).

$$v_b = 2x5 = 10 \text{ V}, \quad v_a = 20/2 = 10 \text{ V}$$

But, $\quad -v_a + V_{Th} + v_b = 0, \text{ or } V_{Th} = v_a - v_b = \underline{\textbf{0 volts}}$

Chapter 4, Problem 44.

For the circuit in Fig. 4.111, obtain the Thevenin equivalent as seen from terminals
(a) ***a-b*** (b) ***b-c***

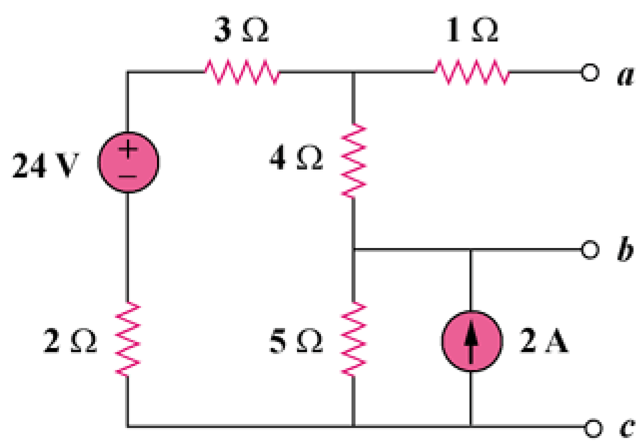


Figure 4.111

Chapter 4, Solution 44.

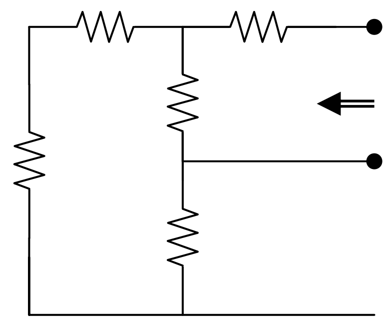
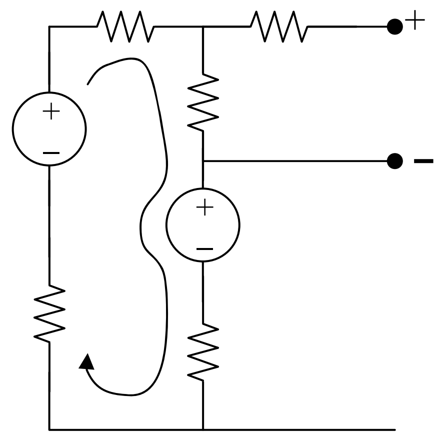
(a) For R_{Th}, consider the circuit in Fig. (a).

$$R_{Th} = 1 + 4||(3 + 2 + 5) = \underline{\textbf{3.857 ohms}}$$

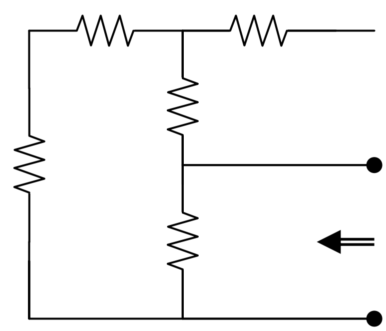
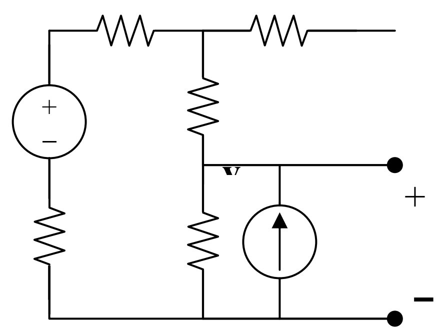
For V_{Th}, consider the circuit in Fig. (b). Applying KVL gives,

$$10 - 24 + i(3 + 4 + 5 + 2), \text{ or } i = 1$$

$$V_{Th} = 4i = \underline{\textbf{4 V}}$$

(b) For R_{Th}, consider the circuit in Fig. (c).

$$R_{Th} = 5||(2 + 3 + 4) = \underline{\textbf{3.214 ohms}}$$

To get V_{Th}, consider the circuit in Fig. (d). At the node, KCL gives,

$$[(24 - vo)/9] + 2 = vo/5, \text{ or } vo = 15$$

$$V_{Th} = vo = \underline{\mathbf{15\ V}}$$

Chapter 4, Problem 45.

Find the Thevenin equivalent of the circuit in Fig. 4.112.

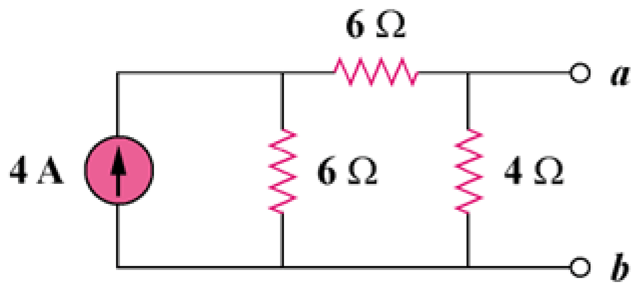
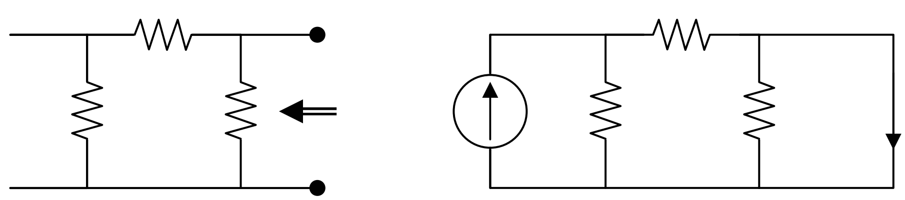


Figure 4.112

Chapter 4, Solution 45.

For R_N, consider the circuit in Fig. (a).



$$R_N = (6 + 6)||4 = \underline{\mathbf{3\ ohms}}$$

For I_N, consider the circuit in Fig. (b). The 4-ohm resistor is shorted so that 4-A current is equally divided between the two 6-ohm resistors. Hence,

$$I_N = 4/2 = \underline{\mathbf{2\ A}}$$

Chapter 4, Problem 46.
Find the Norton equivalent at terminals a-b of the circuit in Fig. 4.113.

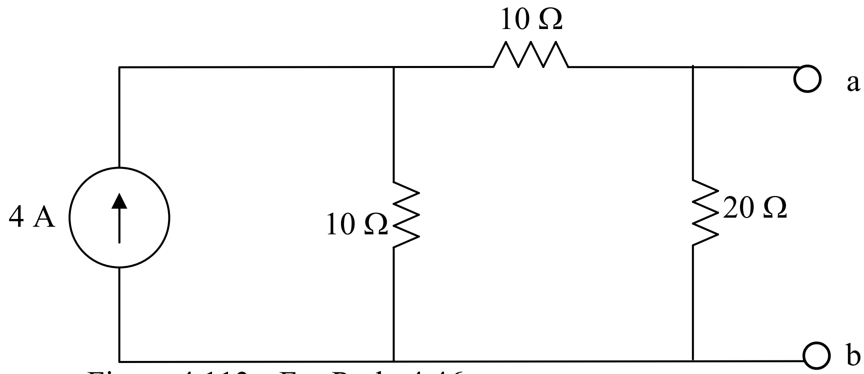
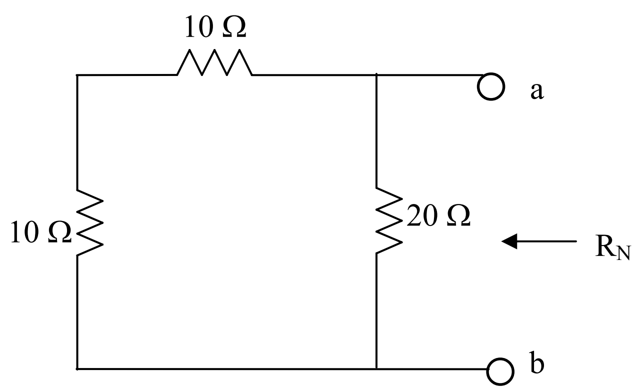
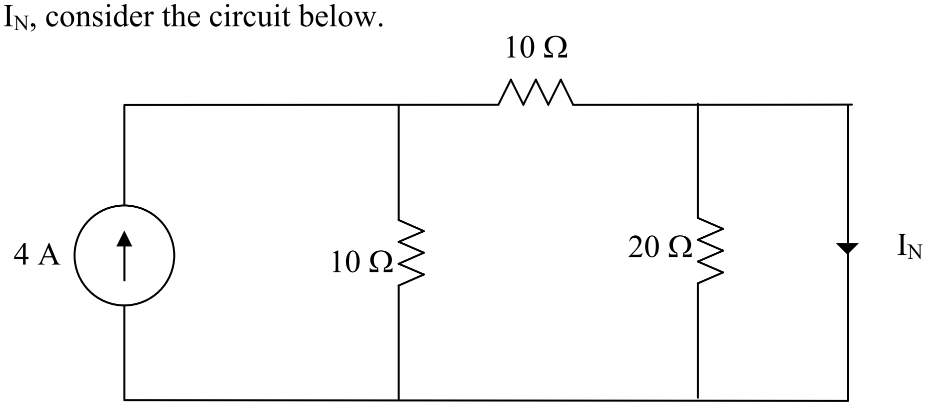


Figure 4.113 For Prob. 4.46.

Chapter 4, Solution 46.
R_N is found using the circuit below.



$R_N = 20//(10+10) = 10\ \Omega$
To find I_N, consider the circuit below.



The 20-Ω resistor is short-circuited and can be ignored.

$$I_N = ½ \text{ x } 4 = \underline{\mathbf{2\ A}}$$

Chapter 4, Problem 47.

Obtain the Thèvenin and Norton equivalent circuits of the circuit in Fig. 4.114 with respect to terminals *a* and *b*.

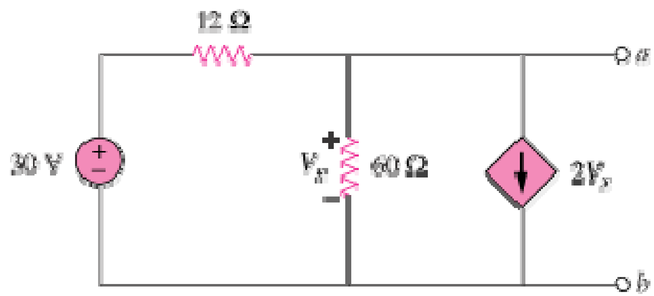


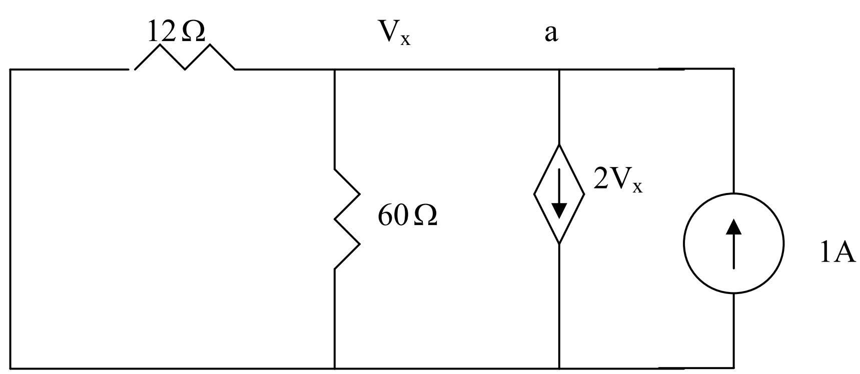
Figure 4.114

Chapter 4, Solution 47

Since $V_{Th} = V_{ab} = V_x$, we apply KCL at the node a and obtain

$$\frac{30 - V_{Th}}{12} = \frac{V_{Th}}{60} + 2V_{Th} \longrightarrow V_{Th} = 150/126 = 1.19 \text{ V}$$

To find R_{Th}, consider the circuit below.



At node a, KCL gives

$$1 = 2V_x + \frac{V_x}{60} + \frac{V_x}{12} \longrightarrow V_x = 60/126 = 0.4762$$

$$R_{Th} = \frac{V_x}{1} = 0.4762\Omega, \qquad I_N = \frac{V_{Th}}{R_{Th}} = 1.19/0.4762 = 2.5$$

Thus,

$$\underline{V_{Th} = 1.19V, \quad R_{Th} = R_N = 0.4762\Omega, \quad I_N = 2.5 \text{ A}}$$

Chapter 4, Problem 48.

Determine the Norton equivalent at terminals ***a-b*** for the circuit in Fig. 4.115.

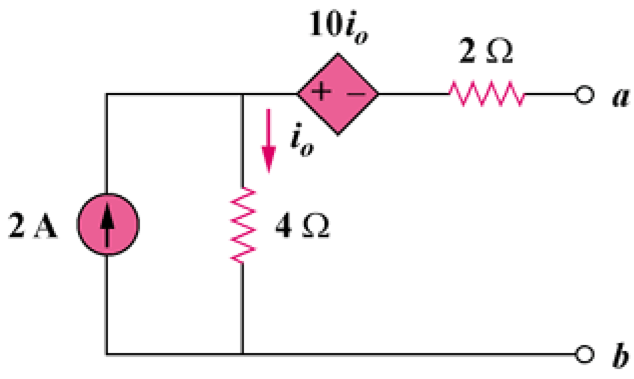
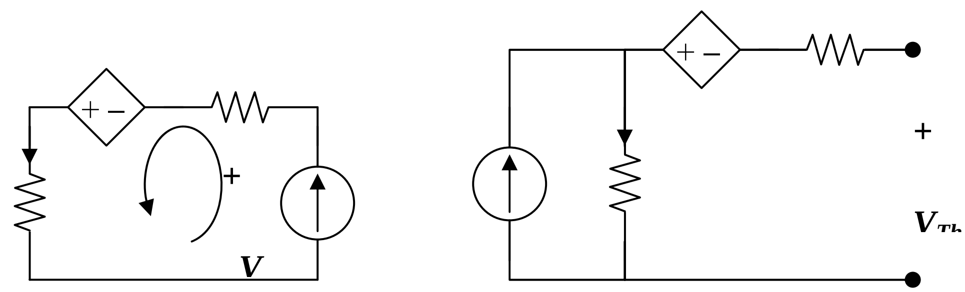


Figure 4.115

Chapter 4, Solution 48.

To get R_{Th}, consider the circuit in Fig. (a).



From Fig. (a), $I_o = 1$, $6 - 10 - V = 0$, or $V = -4$

$$R_N = R_{Th} = V/1 = \underline{\mathbf{-4\ ohms}}$$

To get V_{Th}, consider the circuit in Fig. (b),

$$I_o = 2, \ V_{Th} = -10I_o + 4I_o = -12\ V$$

$$I_N = V_{Th}/R_{Th} = \underline{\mathbf{3A}}$$

Chapter 4, Problem 49.

Find the Norton equivalent looking into terminals ***a-b*** of the circuit in Fig. 4.102.

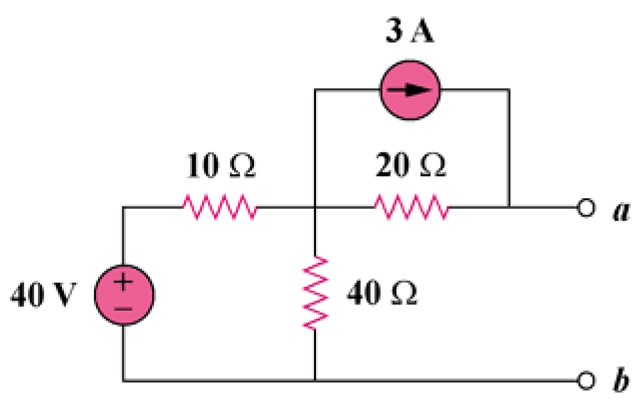
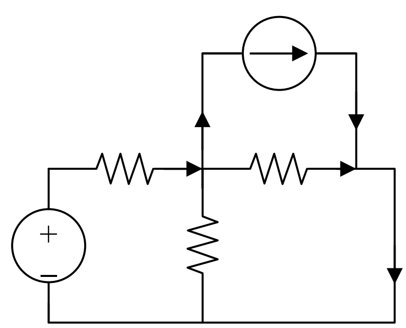


Figure 4.102

Chapter 4, Solution 49.

$R_N = R_{Th} =$ **<u>28 ohms</u>**

To find I_N, consider the circuit below,



At the node, $(40 - v_o)/10 = 3 + (v_o/40) + (v_o/20)$, or $v_o = 40/7$

$i_o = v_o/20 = 2/7$, but $I_N = I_{sc} = i_o + 3 =$ **<u>3.286 A</u>**

Chapter 4, Problem 50.

Obtain the Norton equivalent of the circuit in Fig. 4.116 to the left of terminals ***a-b***. Use the result to find current ***i***

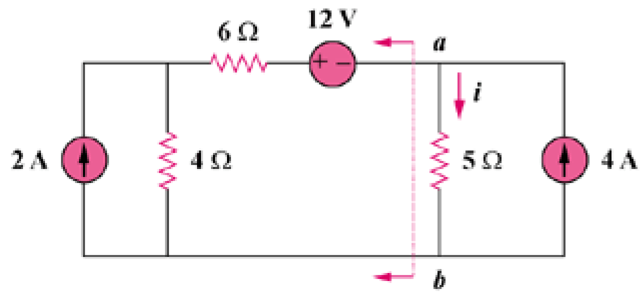
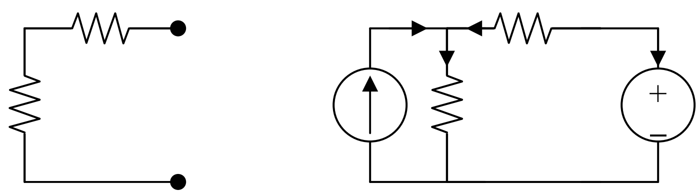


Figure 4.116

Chapter 4, Solution 50.

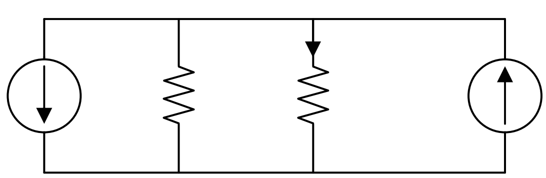
From Fig. (a), $R_N = 6 + 4 =$ **<u>10 ohms</u>**



From Fig. (b), $2 + (12 - v)/6 = v/4$, or $v = 9.6$ V

$-I_N = (12 - v)/6 = 0.4$, which leads to $I_N =$ **<u>-0.4 A</u>**

Combining the Norton equivalent with the right-hand side of the original circuit produces the circuit in Fig. (c).



$i = [10/(10 + 5)]\,(4 - 0.4) =$ **<u>2.4 A</u>**

Chapter 4, Problem 51.

Given the circuit in Fig. 4.117, obtain the Norton equivalent as viewed from terminals
(a) ***a-b*** (b) ***c-d***

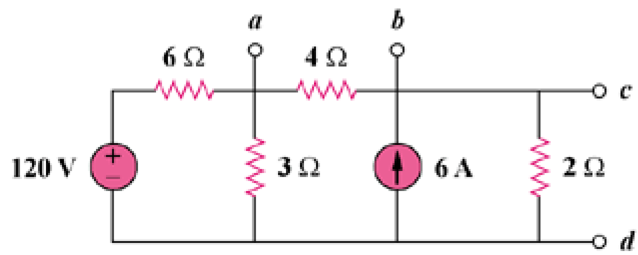
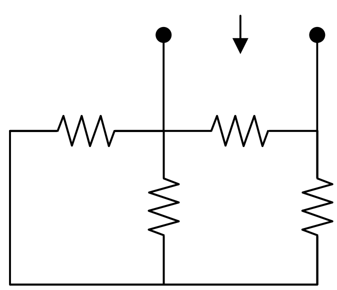


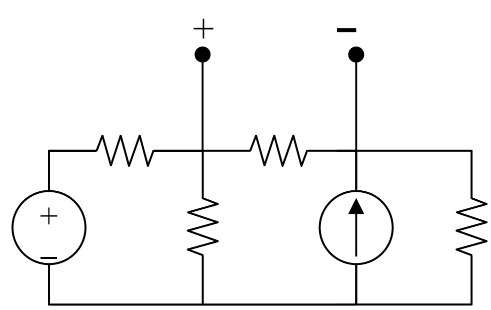
Figure 4.117

Chapter 4, Solution 51.

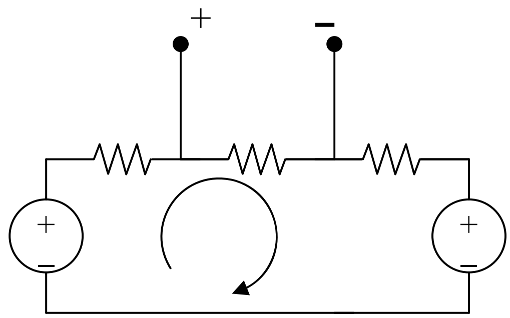
(a) From the circuit in Fig. (a),

$$R_N = 4\|(2 + 6\|3) = 4\|4 = \underline{\mathbf{2\ ohms}}$$





For I_N or V_{Th}, consider the circuit in Fig. (b). After some source transformations, the circuit becomes that shown in Fig. (c).



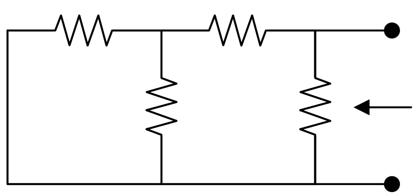
Applying KVL to the circuit in Fig. (c),

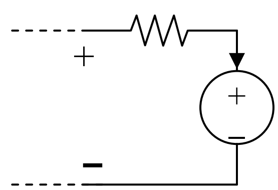
$$-40 + 8i + 12 = 0 \text{ which gives } i = 7/2$$

$$V_{Th} = 4i = 14 \text{ therefore } I_N = V_{Th}/R_N = 14/2 = \underline{\mathbf{7\ A}}$$

(b) To get R_N, consider the circuit in Fig. (d).

$$R_N = 2||(4 + 6||3) = 2||6 = \underline{\mathbf{1.5\ ohms}}$$





To get I_N, the circuit in Fig. (c) applies except that it needs slight modification as in Fig. (e).

$$i = 7/2,\ V_{Th} = 12 + 2i = 19,\ I_N = V_{Th}/R_N = 19/1.5 = \underline{\mathbf{12.667\ A}}$$

Chapter 4, Problem 52.

For the transistor model in Fig. 4.118, obtain the Thevenin equivalent at terminals ***a-b***.

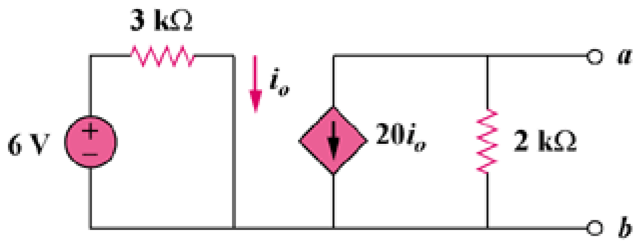
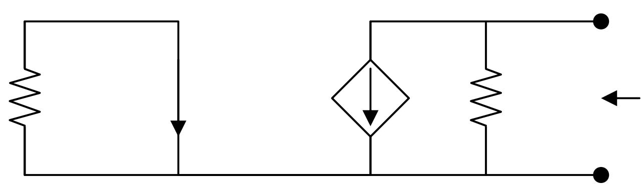
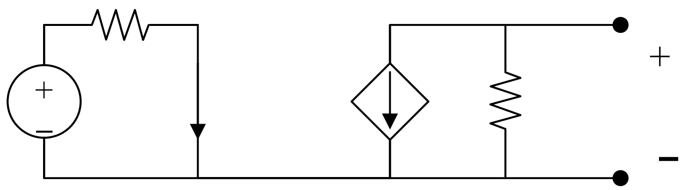


Figure 4.118

Chapter 4, Solution 52.

For R_{Th}, consider the circuit in Fig. (a).





For Fig. (a), $I_o = 0$, hence the current source is inactive and

$$R_{Th} = \underline{\textbf{2 k ohms}}$$

For V_{Th}, consider the circuit in Fig. (b).

$$I_o = 6/3k = 2 \text{ mA}$$

$$V_{Th} = (-20I_o)(2k) = -20x2x10^{-3}x2x10^3 = \underline{\textbf{-80 V}}$$

Chapter 4, Problem 53.

Find the Norton equivalent at terminals ***a-b*** of the circuit in Fig. 4.119.

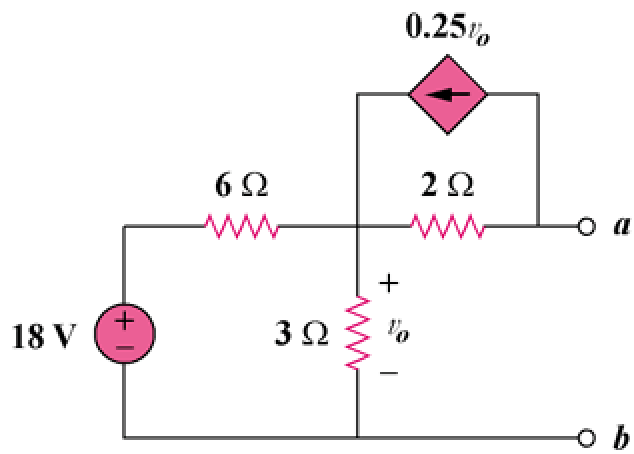
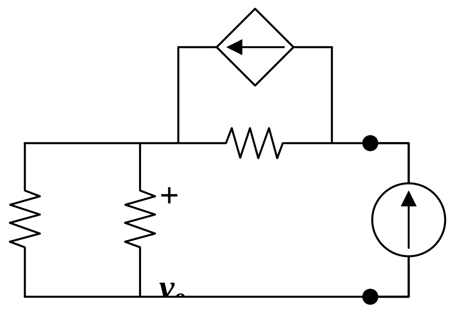
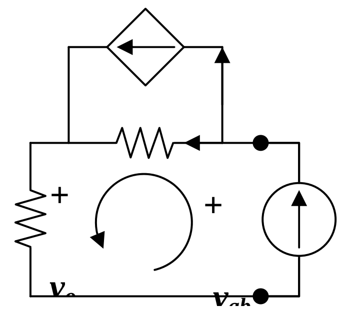


Figure 4.119

Chapter 4, Solution 53.

To get R_{Th}, consider the circuit in Fig. (a).





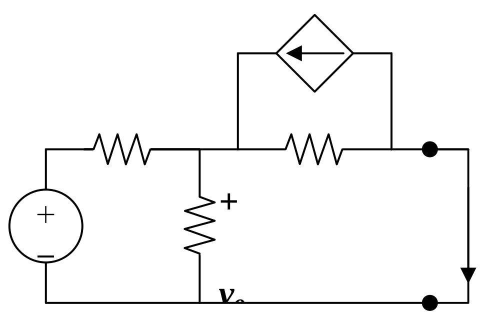
From Fig. (b),

$$v_o = 2x1 = 2V, \ -v_{ab} + 2x(1/2) + v_o = 0$$

$$v_{ab} = 3V$$

$$R_N = v_{ab}/1 = \underline{\mathbf{3\ ohms}}$$

To get I_N, consider the circuit in Fig. (c).



$$[(18 - v_o)/6] + 0.25v_o = (v_o/2) + (v_o/3) \ \text{ or } \ v_o = 4V$$

But, $\quad (v_o/2) = 0.25v_o + I_N$, which leads to $I_N = \underline{\mathbf{1\ A}}$

Chapter 4, Problem 54.

Find the Thèvenin equivalent between terminals *a*-*b* of the circuit in Fig. 4.120.

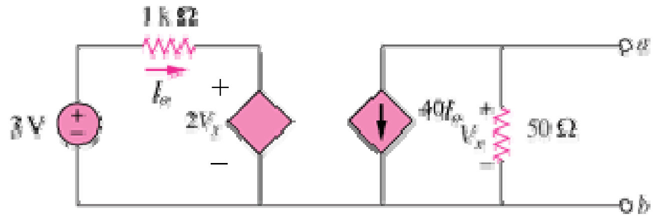


Figure 4.120

Chapter 4, Solution 54

To find $V_{Th} = V_x$, consider the left loop.

$$-3+1000i_o+2V_x=0 \quad \longrightarrow \quad 3=1000i_o+2V_x \qquad (1)$$

For the right loop,

$$V_x = -50x40i_o = -2000i_o \qquad (2)$$

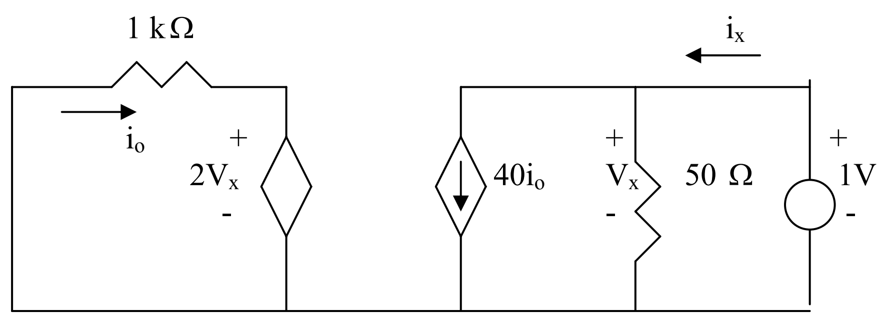
Combining (1) and (2),

$$3=1000i_o-4000i_o=-3000i_o \quad \longrightarrow \quad i_o=-1\text{mA}$$

$$V_x=-2000i_o=2 \quad \longrightarrow \quad \underline{V_{Th}=2}$$

To find R_{Th}, insert a 1-V source at terminals a-b and remove the 3-V independent source, as shown below.

.



$$V_x=1, \qquad i_o=-\frac{2V_x}{1000}=-2\text{mA}$$

$$i_x=40i_o+\frac{V_x}{50}=-80\text{mA}+\frac{1}{50}\text{A}=\text{-60mA}$$

$$R_{Th} = \frac{1}{i_x} = -1/0.060 = \underline{-16.67\Omega}$$

Chapter 4, Problem 55.

Obtain the Norton equivalent at terminals ***a-b*** of the circuit in Fig. 4.121.

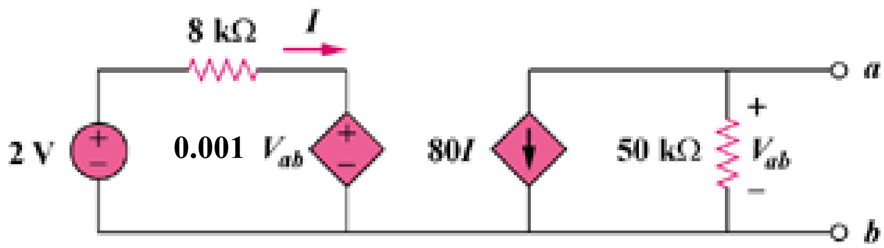
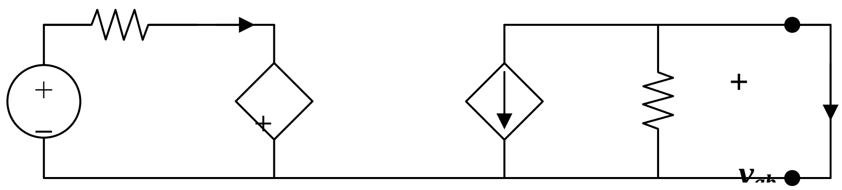


Figure 4.121

Chapter 4, Solution 55.

To get R_N, apply a 1 mA source at the terminals a and b as shown in Fig. (a).



We assume all resistances are in k ohms, all currents in mA, and all voltages in volts. At node a,

$$(v_{ab}/50) + 80I = 1 \qquad (1)$$

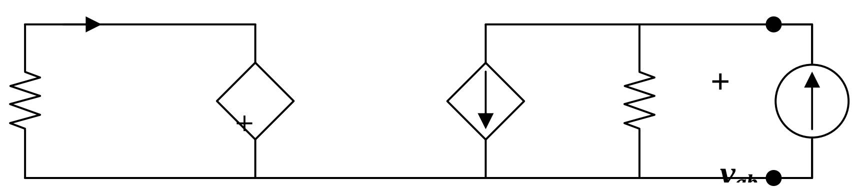
Also,

$$-8I = (v_{ab}/1000), \text{ or } I = -v_{ab}/8000 \qquad (2)$$

From (1) and (2), $(v_{ab}/50) - (80v_{ab}/8000) = 1$, or $v_{ab} = 100$

$$R_N = v_{ab}/1 = \underline{\textbf{100 k ohms}}$$

To get I_N, consider the circuit in Fig. (b).



Since the 50-k ohm resistor is shorted,

$$I_N = -80I, \; v_{ab} = 0$$

Hence, $8i = 2$ which leads to $I = (1/4)$ mA

$$I_N = \underline{\textbf{-20 mA}}$$

Chapter 4, Problem 56.

Use Norton's theorem to find V_o in the circuit of Fig. 4.122.

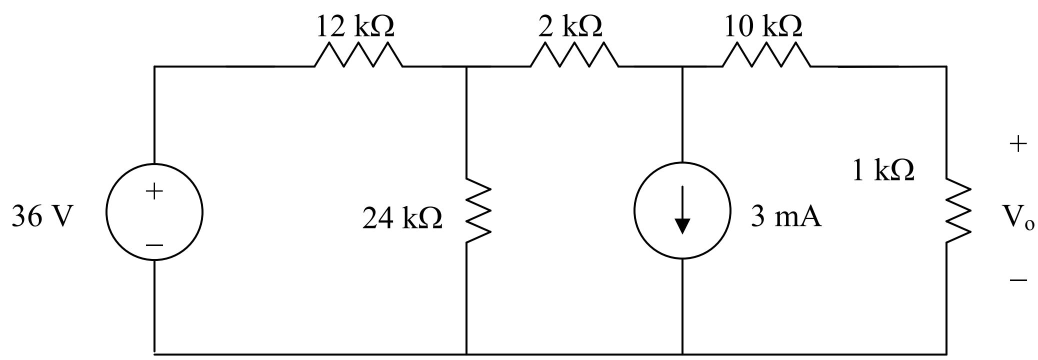
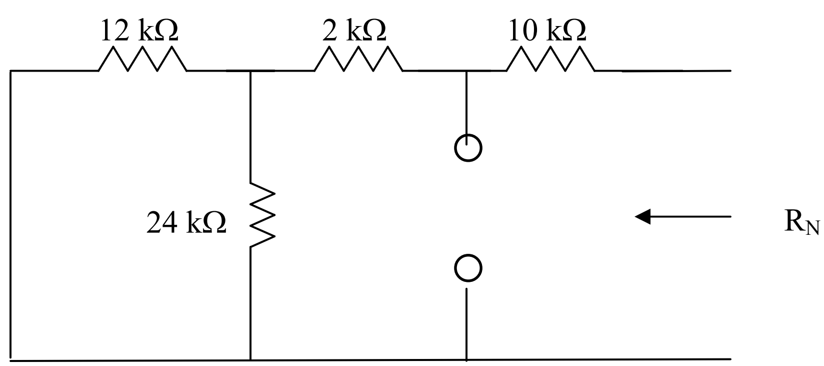


Figure 4.122 For Prob. 4.56.

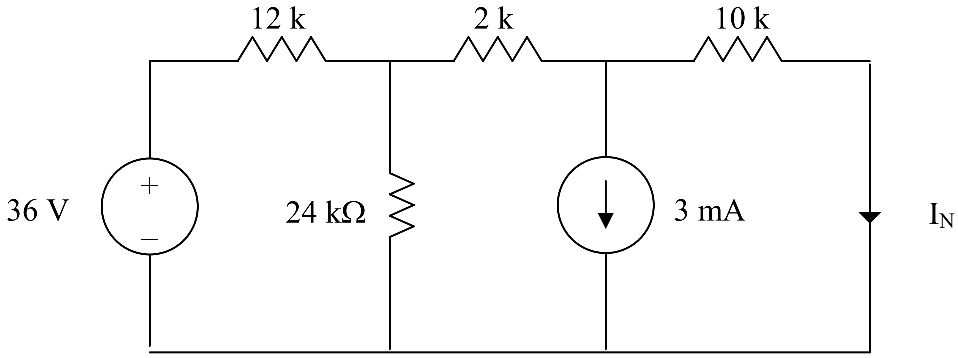
Chapter 4, Solution 56.

We remove the 1-kΩ resistor temporarily and find Norton equivalent across its terminals. R_N is obtained from the circuit below.

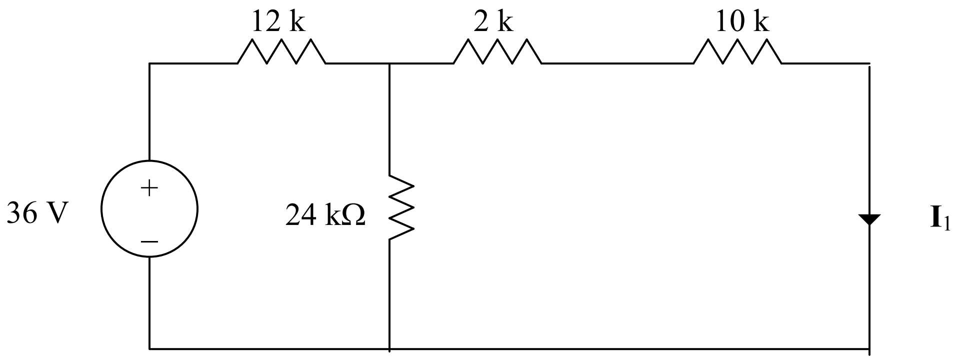


$R_N = 10 + 2 + 12//24 = 12+8 = 20$ kΩ

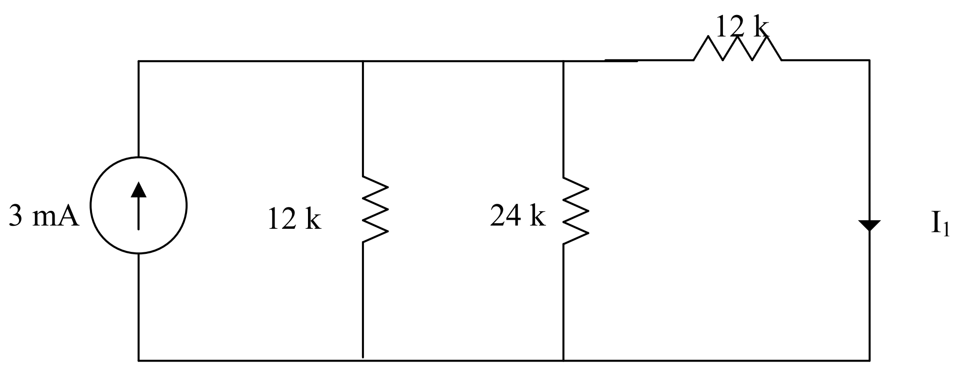
I_N is obtained from the circuit below.



We can use superposition theorem to find I_N. Let $I_N = I_1 + I_2$, where I_1 and I_2 are due to 16-V and 3-mA sources respectively. We find I_1 using the circuit below.



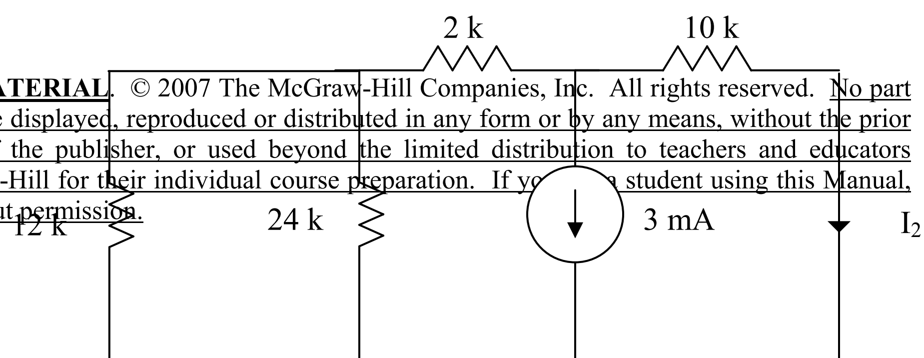
Using source transformation, we obtain the circuit below.



12//24 = 8 kΩ

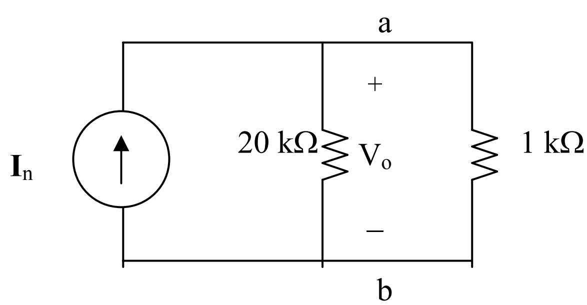
$$I_1 = \frac{8}{8+12}(3mA) = 1.2 \text{ mA}$$

To find I_2, consider the circuit below.



$2k + 12k//24\ k\ \ = 10\ k\Omega$
$I_2 = 0.5(-3mA) = -1.5\ mA$
$I_N = 1.2 - 1.5 = -0.3\ mA$

The Norton equivalent with the 1-kΩ resistor is shown below



$$V_o = 1k\left(\frac{20}{20+1}\right)(-0.3\ mA) = \underline{-0.2857\ V}$$

Chapter 4, Problem 57.

Obtain the Thevenin and Norton equivalent circuits at the terminals ***a-b*** for the circuit in Fig. 4.123.

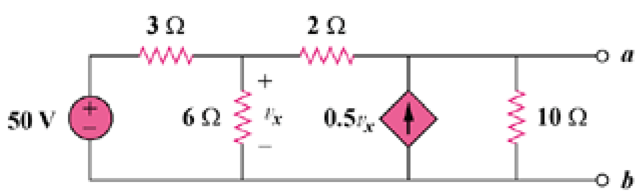
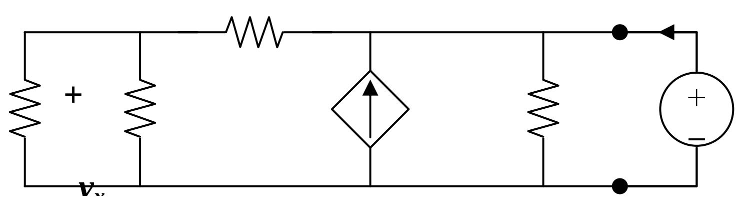


Figure 4.123

Chapter 4, Solution 57.

To find R_{Th}, remove the 50V source and insert a 1-V source at a – b, as shown in Fig. (a).



We apply nodal analysis. At node A,

$$i + 0.5v_x = (1/10) + (1 - v_x)/2, \text{ or } i + v_x = 0.6 \qquad (1)$$

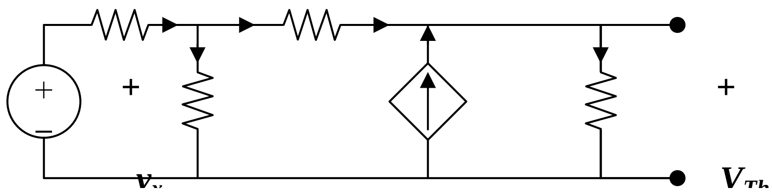
At node B,

$$(1 - v_o)/2 = (v_x/3) + (v_x/6), \text{ and } v_x = 0.5 \qquad (2)$$

From (1) and (2), $\quad i = 0.1$ and

$$R_{Th} = 1/i = \underline{\mathbf{10\ ohms}}$$

To get V_{Th}, consider the circuit in Fig. (b).



At node 1, $\quad (50 - v_1)/3 = (v_1/6) + (v_1 - v_2)/2$, or $100 = 6v_1 - 3v_2$ $\quad$ (3)

At node 2, $\quad 0.5v_x + (v_1 - v_2)/2 = v_2/10$, $v_x = v_1$, and $v_1 = 0.6v_2$ $\quad$ (4)

From (3) and (4),

$$v_2 = V_{Th} = \underline{\mathbf{166.67\ V}}$$

$$I_N = V_{Th}/R_{Th} = \underline{\mathbf{16.667\ A}}$$

$$R_N = R_{Th} = \underline{\mathbf{10\ ohms}}$$

Chapter 4, Problem 58.

The network in Fig. 4.124 models a bipolar transistor common-emitter amplifier connected to a load. Find the Thevenin resistance seen by the load.

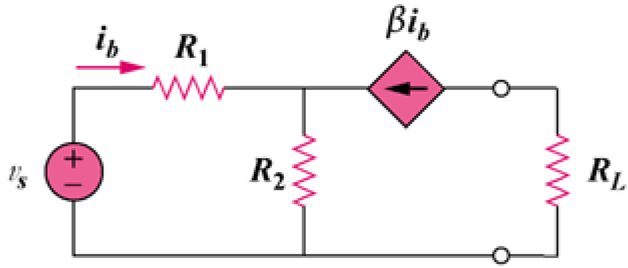
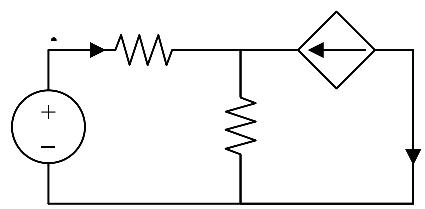


Figure 4.124

Chapter 4, Solution 58.

This problem does not have a solution as it was originally stated. The reason for this is that the load resistor is in series with a current source which means that the only equivalent circuit that will work will be a Norton circuit where the value of R_N = **infinity**. I_N can be found by solving for I_{sc}.



Writing the node equation at node v_o,

$$i_b + \beta i_b = v_o/R_2 = (1 + \beta)i_b$$

But $$i_b = (V_s - v_o)/R_1$$

$$v_o = V_s - i_b R_1$$

$$V_s - i_b R_1 = (1 + \beta)R_2 i_b, \text{ or } i_b = V_s/(R_1 + (1 + \beta)R_2)$$

$$I_{sc} = I_N = -\beta i_b = \underline{\mathbf{-\beta V_s/(R_1 + (1 + \beta)R_2)}}$$

Chapter 4, Problem 59.

Determine the Thevenin and Norton equivalents at terminals ***a-b*** of the circuit in Fig. 4.125.

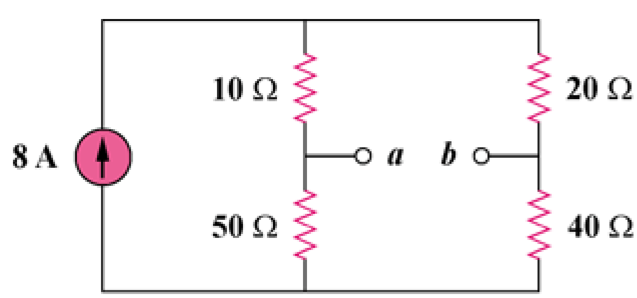
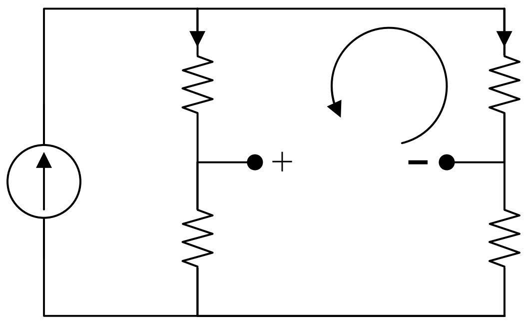


Figure 4.125

Chapter 4, Solution 59.

R_{Th} = (10 + 20)||(50 + 40) 30||90 = **<u>22.5 ohms</u>**

To find V_{Th}, consider the circuit below.



$$i_1 = i_2 = 8/2 = 4, \; 10i_1 + V_{Th} - 20i_2 = 0, \text{ or } V_{Th} = 20i_2 - 10i_1 = 10i_1 = 10x4$$

$$V_{Th} = \underline{\mathbf{40V}}, \text{ and } I_N = V_{Th}/R_{Th} = 40/22.5 = \underline{\mathbf{1.7778\ A}}$$

Chapter 4, Problem 60.

For the circuit in Fig. 4.126, find the Thevenin and Norton equivalent circuits at terminals ***a-b***.

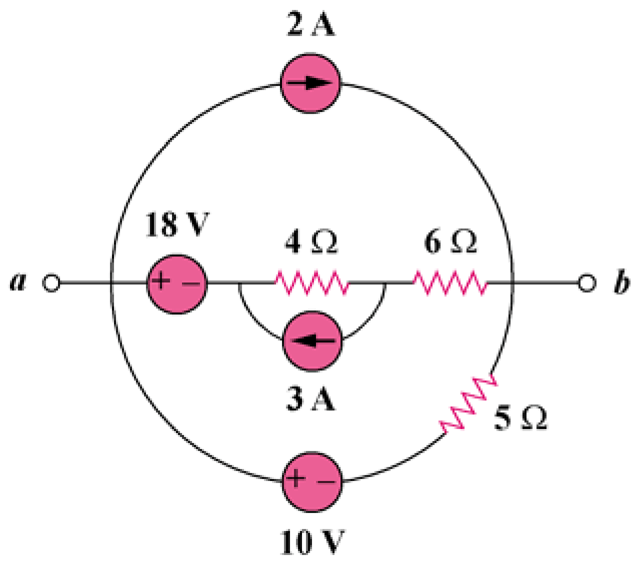
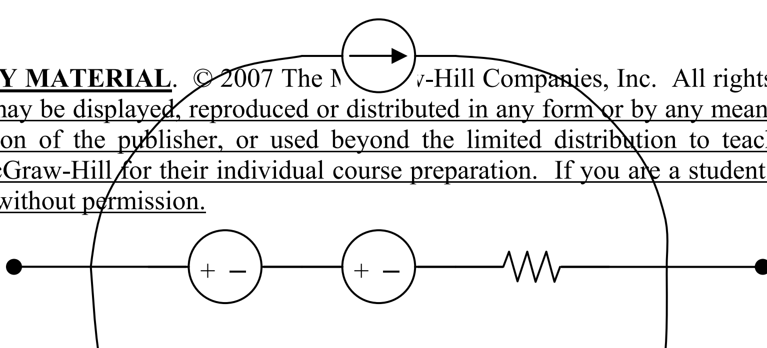
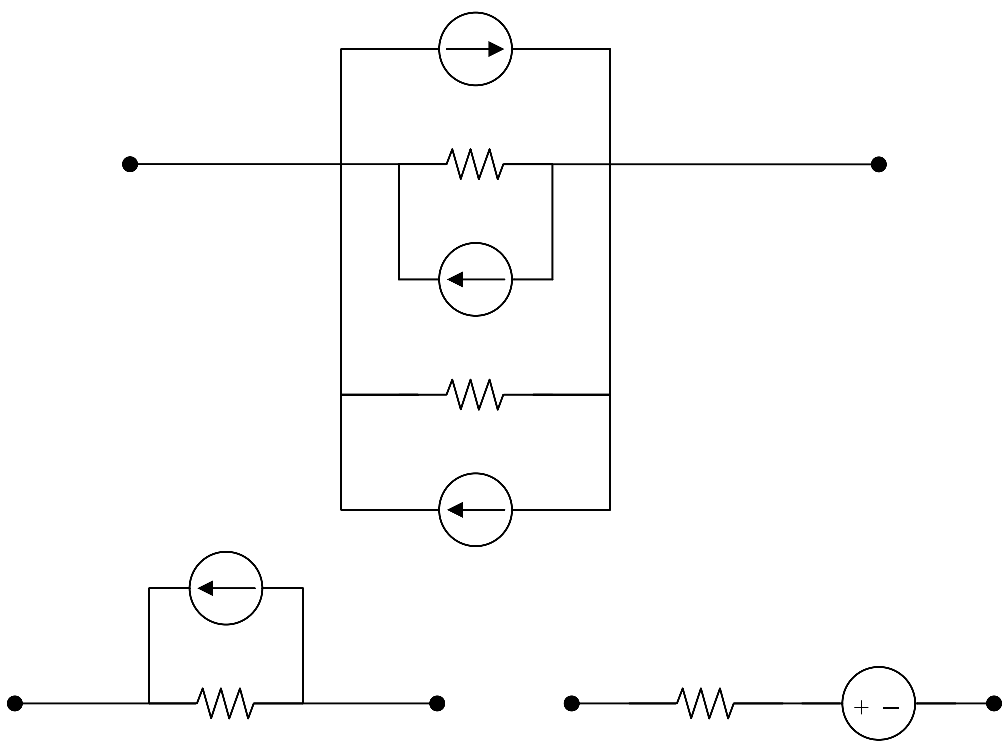


Figure 4.126

Chapter 4, Solution 60.

The circuit can be reduced by source transformations.





Chapter 4, Problem 61.

Obtain the Thevenin and Norton equivalent circuits at terminals ***a-b*** of the circuit in Fig. 4.127.

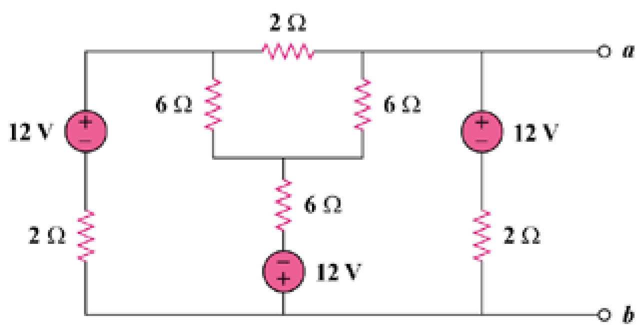


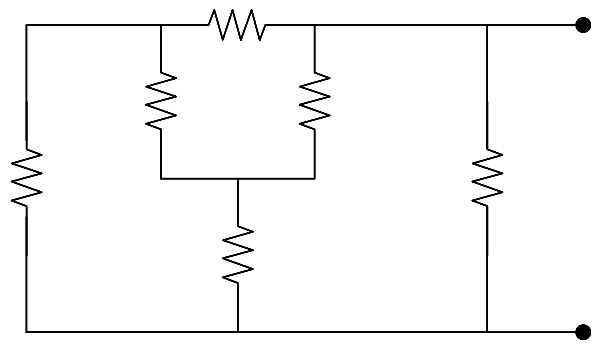
Figure 4.127

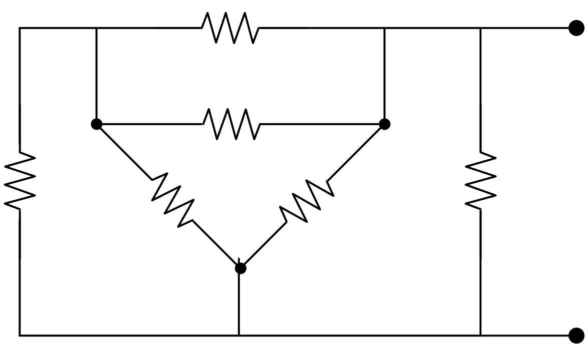
Chapter 4, Solution 61.

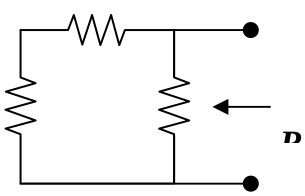
To find R_{Th}, consider the circuit in Fig. (a).

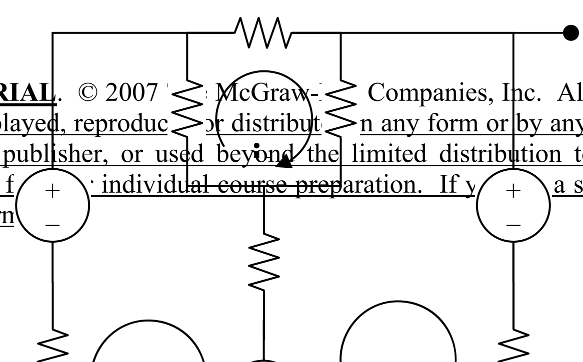
Let $\quad R = 2||18 =$ **1.8 ohms**, $\qquad R_{Th} = 2R||R = (2/3)R =$ **1.2 ohms**.

To get V_{Th}, we apply mesh analysis to the circuit in Fig. (d).









$-12 - 12 + 14i_1 - 6i_2 - 6i_3 = 0$, and $7 i_1 - 3 i_2 - 3i_3 = 12$ (1)

$12 + 12 + 14 i_2 - 6 i_1 - 6 i_3 = 0$, and $-3 i_1 + 7 i_2 - 3 i_3 = -12$ (2)

$14 i_3 - 6 i_1 - 6 i_2 = 0$, and $-3 i_1 - 3 i_2 + 7 i_3 = 0$ (3)

This leads to the following matrix form for (1), (2) and (3),

$$\begin{bmatrix} 7 & -3 & -3 \\ -3 & 7 & -3 \\ -3 & -3 & 7 \end{bmatrix} \begin{bmatrix} i_1 \\ i_2 \\ i_3 \end{bmatrix} = \begin{bmatrix} 12 \\ -12 \\ 0 \end{bmatrix}$$

$$\Delta = \begin{vmatrix} 7 & -3 & -3 \\ -3 & 7 & -3 \\ -3 & -3 & 7 \end{vmatrix} = 100, \qquad \Delta_2 = \begin{vmatrix} 7 & 12 & -3 \\ -3 & -12 & -3 \\ -3 & 0 & 7 \end{vmatrix} = -120$$

$$i_2 = \Delta/\Delta_2 = -120/100 = -1.2 \text{ A}$$

$V_{Th} = 12 + 2i_2 =$ **<u>9.6 V</u>**, and $I_N = V_{Th}/R_{Th} =$ **<u>8 A</u>**

Chapter 4, Problem 62.

Find the Thevenin equivalent of the circuit in Fig. 4.128.

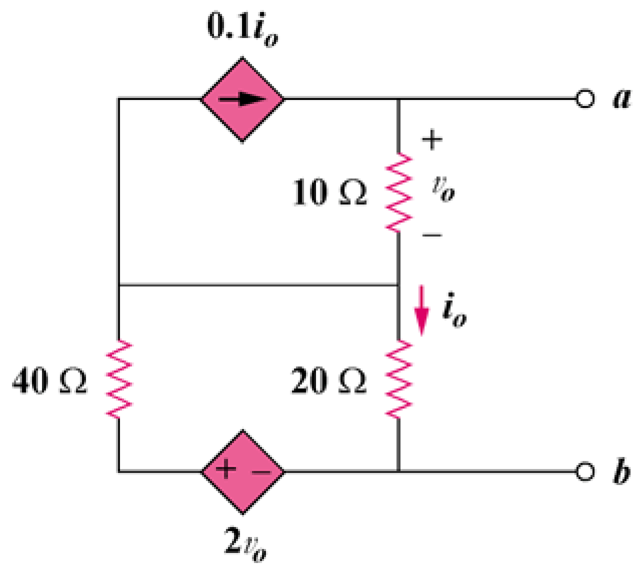
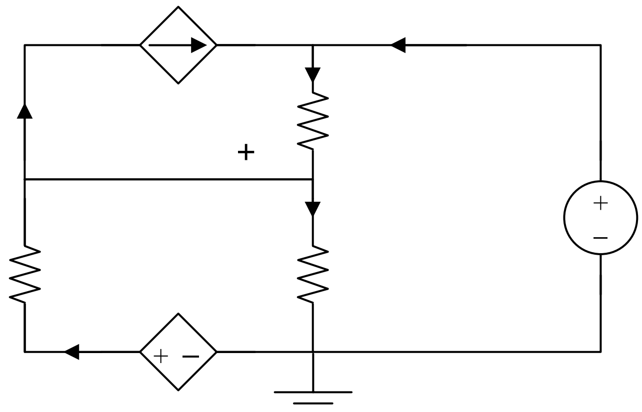


Figure 4.128

Chapter 4, Solution 62.

Since there are no independent sources, V_{Th} = 0 V

To obtain R_{Th}, consider the circuit below.



At node 2,

$$i_x + 0.1i_o = (1 - v_1)/10, \text{ or } 10i_x + i_o = 1 - v_1 \qquad (1)$$

At node 1,

$$(v_1/20) + 0.1i_o = [(2v_o - v_1)/40] + [(1 - v_1)/10] \qquad (2)$$

But $i_o = (v_1/20)$ and $v_o = 1 - v_1$, then (2) becomes,

$$1.1v_1/20 = [(2 - 3v_1)/40] + [(1 - v_1)/10]$$

$$2.2v_1 = 2 - 3v_1 + 4 - 4v_1 = 6 - 7v_1$$

or

$$v_1 = 6/9.2 \qquad (3)$$

From (1) and (3),

$$10i_x + v_1/20 = 1 - v_1$$

$$10i_x = 1 - v_1 - v_1/20 = 1 - (21/20)v_1 = 1 - (21/20)(6/9.2)$$

$$i_x = 31.52 \text{ mA}, \ R_{Th} = 1/i_x = \underline{\mathbf{31.73\ ohms.}}$$

Chapter 4, Problem 63.

Find the Norton equivalent for the circuit in Fig. 4.129.

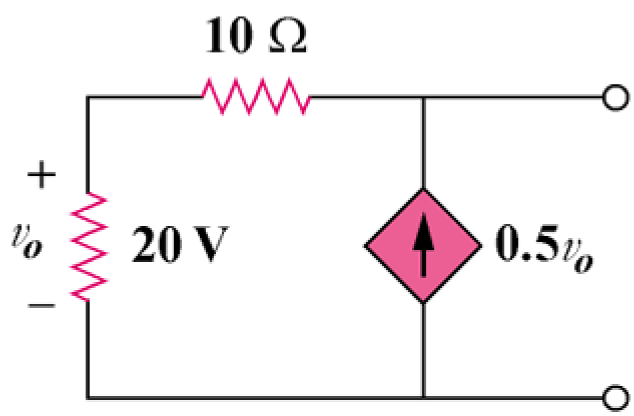
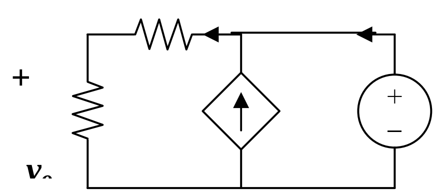


Figure 4.129

Chapter 4, Solution 63.

Because there are no independent sources, $I_N = I_{sc} =$ **<u>0 A</u>**

R_N can be found using the circuit below.



Applying KCL at node 1, $v_1 = 1$, and $v_o = (20/30)v_1 = 2/3$

$i_o = (v_1/30) - 0.5v_o = (1/30) - 0.5x2/3 = 0.03333 - 0.33333 = -0.3$ A.

Hence,

$R_N = 1/(-0.3) =$ **<u>–3.333 ohms</u>**

Chapter 4, Problem 64.

Obtain the Thevenin equivalent seen at terminals ***a-b*** of the circuit in Fig. 4.130.

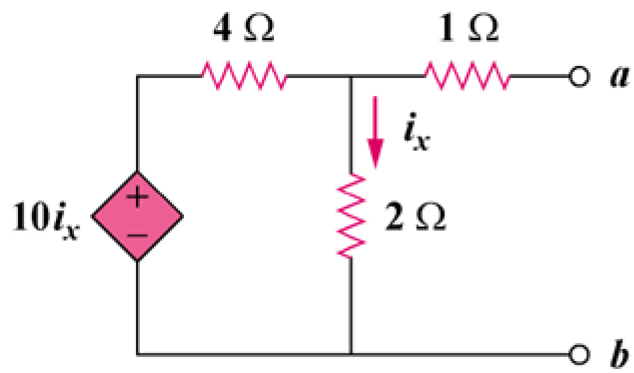
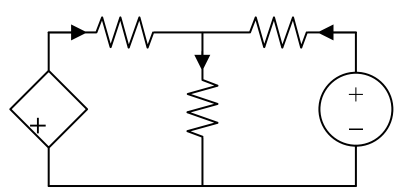


Figure 4.130

Chapter 4, Solution 64.

With no independent sources, V_{Th} = **0 V**. To obtain R_{Th}, consider the circuit shown below.



$$i_x = [(1 - v_o)/1] + [(10i_x - v_o)/4], \text{ or } 5v_o = 4 + 6i_x \qquad (1)$$

But $i_x = v_o/2$. Hence,

$$5v_o = 4 + 3v_o, \text{ or } v_o = 2, \; i_o = (1 - v_o)/1 = -1$$

$$\text{Thus, } R_{Th} = 1/i_o = \underline{\mathbf{-1\ ohm}}$$

Chapter 4, Problem 65.

For the circuit shown in Fig. 4.131, determine the relationship between V_o and I_o.

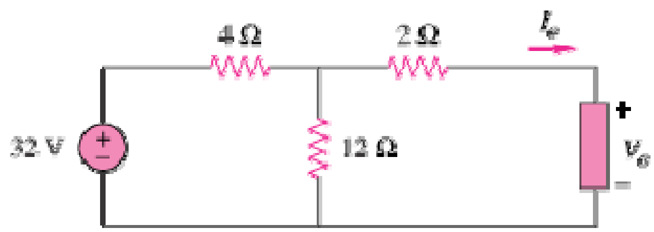


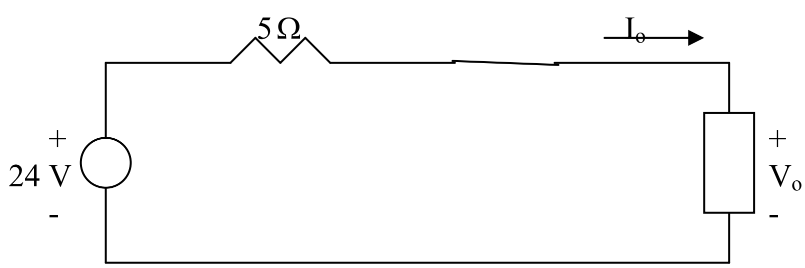
Figure 4.131

Chapter 4, Solution 65

At the terminals of the unknown resistance, we replace the circuit by its Thevenin equivalent.

$R_{Th} = 2 + 4//12 = 2 + 3 = 5\Omega,\qquad V_{Th} = \frac{12}{12+4}(32) = 24\text{ V}$

Thus, the circuit can be replaced by that shown below.



Applying KVL to the loop,

$-24 + 5I_o + V_o = 0 \quad\longrightarrow\quad \underline{V_o = 24 - 5I_o}$

Chapter 4, Problem 66.

Find the maximum power that can be delivered to the resistor ***R*** in the circuit in Fig. 4.132.

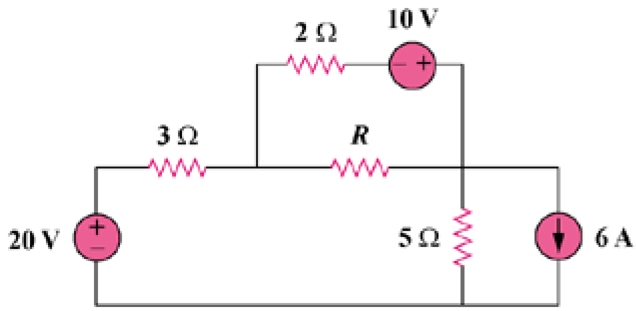
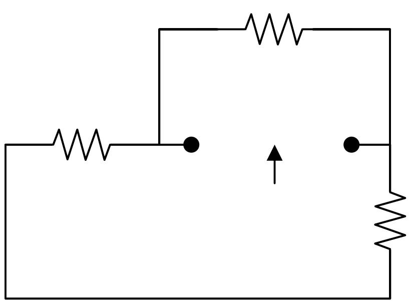
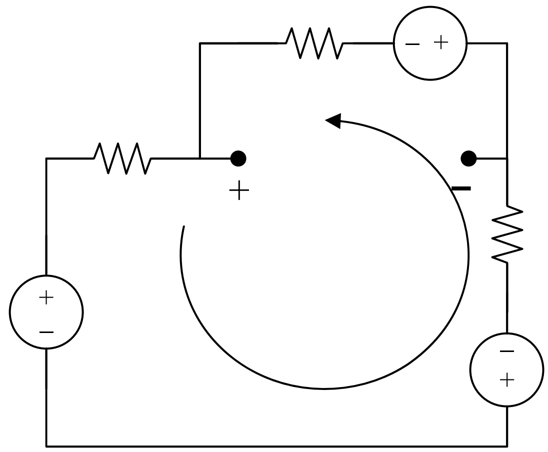


Figure 4.132

Chapter 4, Solution 66.

We first find the Thevenin equivalent at terminals a and b. We find R_{Th} using the circuit in Fig. (a).





$$R_{Th} = 2||(3 + 5) = 2||8 = \underline{\mathbf{1.6\ ohms}}$$

By performing source transformation on the given circuit, we obatin the circuit in (b). We now use this to find V_{Th}.

$$10i + 30 + 20 + 10 = 0, \text{ or } i = -6$$

$$V_{Th} + 10 + 2i = 0, \text{ or } V_{Th} = 2\text{ V}$$

$$p = V_{Th}^2/(4R_{Th}) = (2)^2/[4(1.6)] = \underline{\mathbf{625\ m\ watts}}$$

Chapter 4, Problem 67.

The variable resistor R in Fig. 4.133 is adjusted until it absorbs the maximum power from the circuit. (a) Calculate the value of R for maximum power. (b) Determine the maximum power absorbed by R.

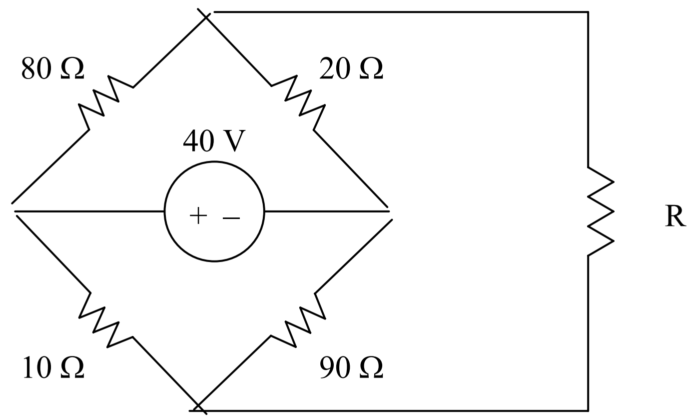
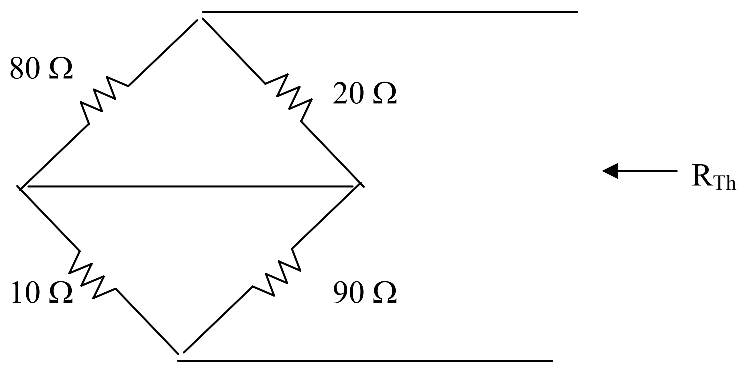


Figure 4.133 For Prob. 4.67.

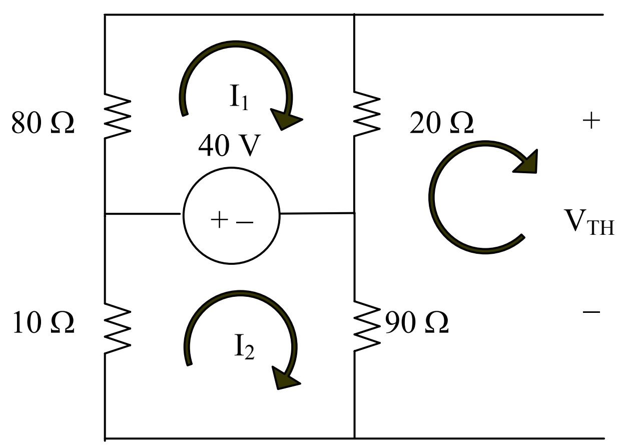
Chapter 4, Solution 67.

We first find the Thevenin equivalent. We find R_{Th} using the circuit below.



$$R_{Th} = 20//80 + 90//10 = 16 + 9 = 25\ \Omega$$

We find V_{Th} using the circuit below. We apply mesh analysis.



$$(80+20)i_1 - 40 = 0 \quad \longrightarrow \quad i_1 = 0.4$$
$$(10+90)i_2 + 40 = 0 \quad \longrightarrow \quad i_2 = -0.4$$
$$-90i_2 - 20i_1 + V_{Th} = 0 \quad \longrightarrow \quad V_{Th} = -28\ \text{V}$$

(a) $R = R_{Th} = \underline{25\ \Omega}$

(b) $P_{max} = \dfrac{V_{Th}^2}{4R_{Th}} = \dfrac{(28)^2}{100} = \underline{7.84\ \text{W}}$

Chapter 4, Problem 68.

Compute the value of ***R*** that results in maximum power transfer to the 10-Ω resistor in Fig. 4.134. Find the maximum power.

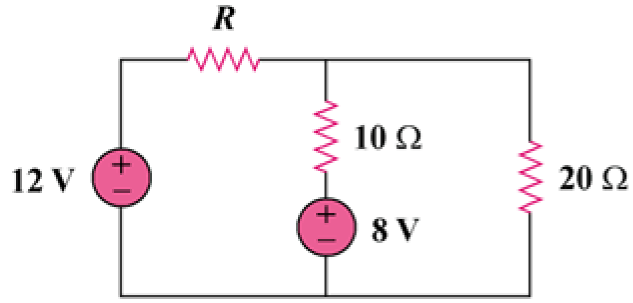
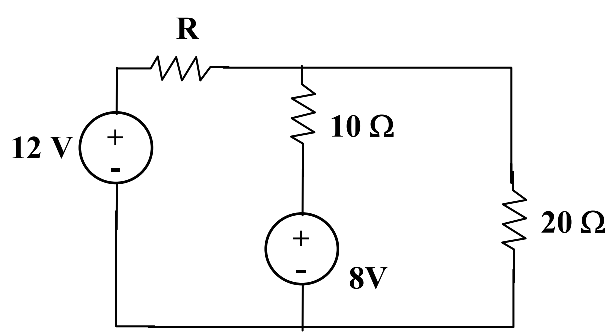


Figure 4.134

Chapter 4, Solution 68.

This is a challenging problem in that the load is already specified. This now becomes a "minimize losses" style problem. When a load is specified and internal losses can be adjusted, then the objective becomes, reduce R_{Thev} as much as possible, which will result in maximum power transfer to the load.



Removing the 10 ohm resistor and solving for the Thevenin Circuit results in:

$$R_{Th} = (Rx20/(R+20)) \text{ and a } V_{oc} = V_{Th} = 12x(20/(R+20)) + (-8)$$

As R goes to zero, R_{Th} goes to zero and V_{Th} goes to 4 volts, which produces the maximum power delivered to the 10-ohm resistor.

$$P = vi = v^2/R = 4x4/10 = 1.6 \text{ watts}$$

Notice that if R = 20 ohms which gives an R_{Th} = 10 ohms, then V_{Th} becomes -2 volts and the power delivered to the load becomes 0.1 watts, much less that the 1.6 watts.

It is also interesting to note that the internal losses for the first case are $12^2/20 = 7.2$ watts and for the second case are = to 12 watts. This is a significant difference.

Chapter 4, Problem 69.

Find the maximum power transferred to resistor ***R*** in the circuit of Fig. 4.135.

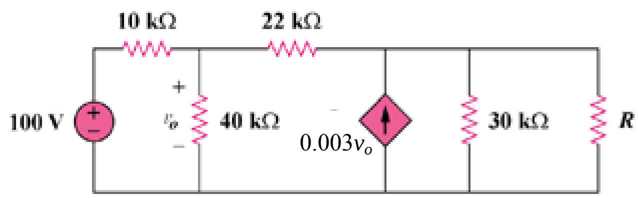
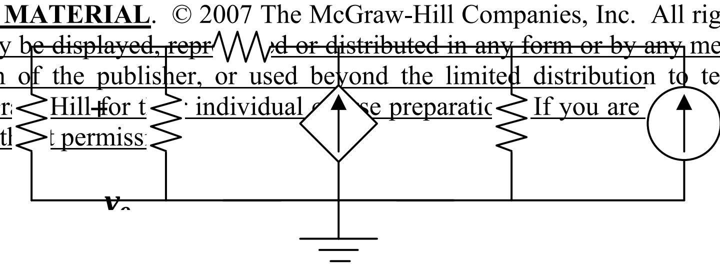


Figure 4.135

Chapter 4, Solution 69.



We need the Thevenin equivalent across the resistor R. To find R_{Th}, consider the circuit below.

Assume that all resistances are in k ohms and all currents are in mA.

$$10 \| 40 = 8, \text{ and } 8 + 22 = 30$$

$$1 + 3v_o = (v_1/30) + (v_1/30) = (v_1/15)$$

$$15 + 45v_o = v_1$$

But $v_o = (8/30)v_1$, hence,

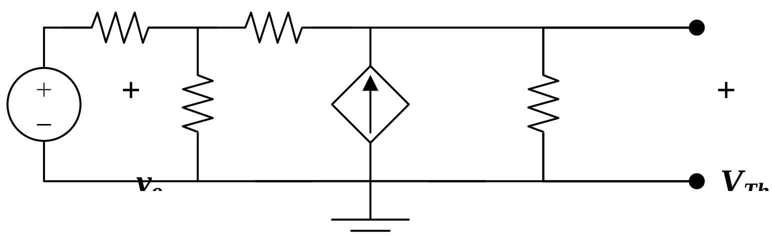
$$15 + 45x(8v_1/30) \;\; v_1, \text{ which leads to } v_1 = 1.3636$$

$$R_{Th} = v_1/1 = -1.3636 \text{ k ohms}$$

R_{Th} being negative indicates an active circuit and if you now make R equal to 1.3636 k ohms, then the active circuit will actually try to supply infinite power to the resistor. The correct answer is therefore:

$$p_R = \left(\frac{V_{Th}}{-1363.6 + 1363.6}\right)^2 1363.6 = \left(\frac{V_{Th}}{0}\right)^2 1363.6 = \underline{\underline{\infty}}$$

It may still be instructive to find V_{Th}. Consider the circuit below.



$$(100 - v_o)/10 = (v_o/40) + (v_o - v_1)/22 \qquad (1)$$

$$[(v_o - v_1)/22] + 3v_o = (v_1/30) \qquad (2)$$

Solving (1) and (2),

$$v_1 = V_{Th} = -243.6 \text{ volts}$$

Chapter 4, Problem 70.

Determine the maximum power delivered to the variable resistor R shown in the circuit of Fig. 4.136.

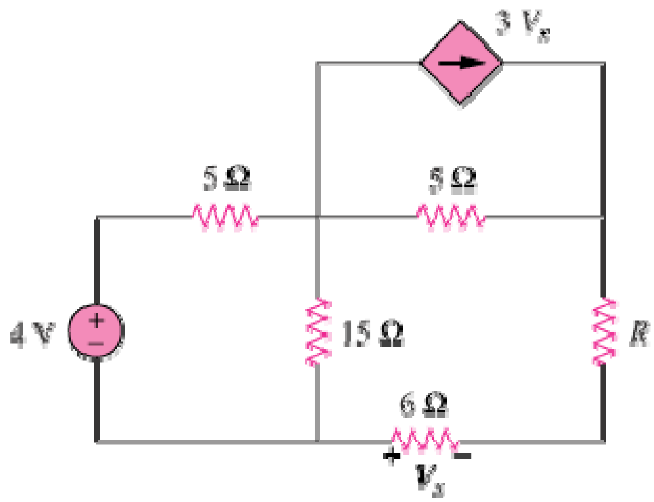
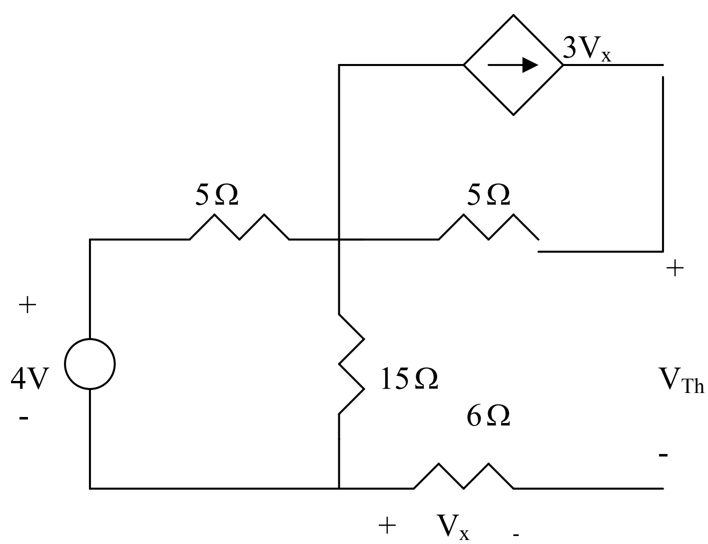


Figure 4.136

Chapter 4, Solution 70

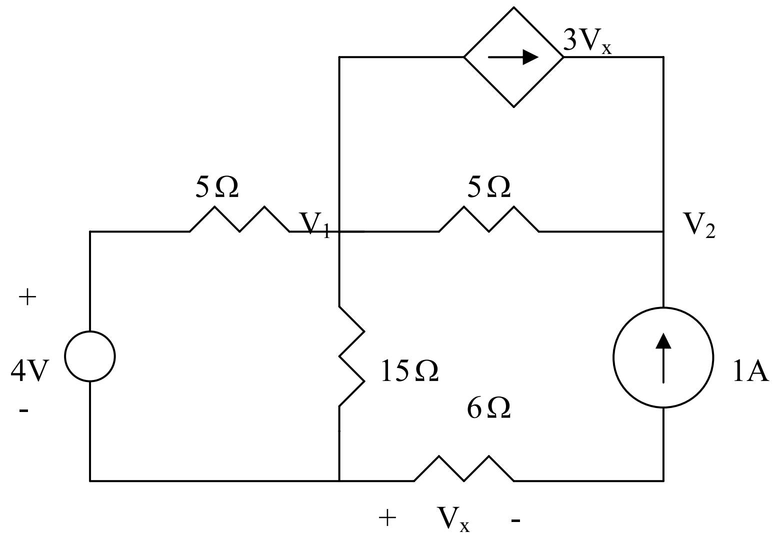
We find the Thevenin equivalent across the 10-ohm resistor. To find V_{Th}, consider the circuit below.



From the figure,

$$V_x = 0, \qquad V_{Th} = \frac{15}{15+5}(4) = 3\text{V}$$

To find $R_{Th,}$ consider the circuit below:



At node 1,

$$\frac{4-V_1}{5} = 3V_x + \frac{V_1}{15} + \frac{V_1 - V_2}{5}, \qquad V_x = 6x1 = 6 \longrightarrow \qquad 258 = 3V_2 - 7V_1 \qquad (1)$$

At node 2,

$$1 + 3V_x + \frac{V_1 - V_2}{5} = 0 \longrightarrow \quad V_1 = V_2 - 95 \qquad (2)$$

Solving (1) and (2) leads to $V_2 = 101.75$ V

$$R_{Th} = \frac{V_2}{1} = 101.75\Omega, \qquad p_{\max} = \frac{V_{Th}^{\ 2}}{4R_{Th}} = \frac{9}{4x101.75} = \underline{22.11\,\text{mW}}$$

Chapter 4, Problem 71.

For the circuit in Fig. 4.137, what resistor connected across terminals ***a-b*** will absorb maximum power from the circuit? What is that power?

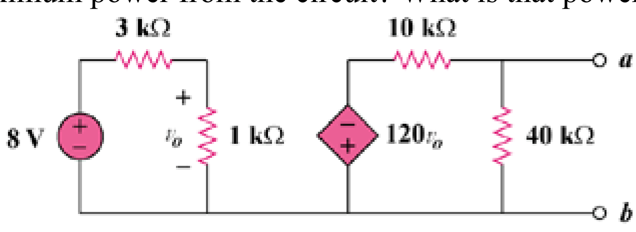
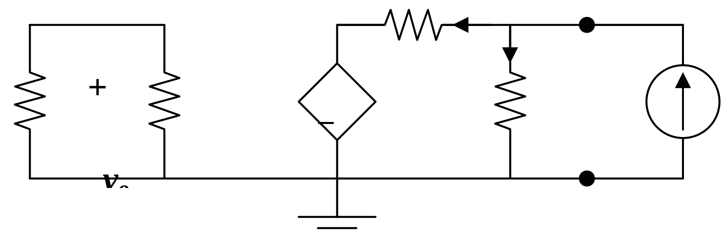


Figure 4.137

Chapter 4, Solution 71.

We need R_{Th} and V_{Th} at terminals a and b. To find R_{Th}, we insert a 1-mA source at the terminals a and b as shown below.



Assume that all resistances are in k ohms, all currents are in mA, and all voltages are in volts. At node a,

$$1 = (v_a/40) + [(v_a + 120v_o)/10], \text{ or } 40 = 5v_a + 480v_o \qquad (1)$$

The loop on the left side has no voltage source. Hence, $v_o = 0$. From (1), $v_a = 8$ V.

$$R_{Th} = v_a/1 \text{ mA} = 8 \text{ kohms}$$

To get V_{Th}, consider the original circuit. For the left loop,

$$v_o = (1/4)8 = 2 \text{ V}$$

For the right loop, $v_R = V_{Th} = (40/50)(-120v_o) = -192$

The resistance at the required resistor is

$$R = R_{Th} = \underline{\textbf{8 kohms}}$$

$$p = V_{Th}^2/(4R_{Th}) = (-192)^2/(4\text{x}8\text{x}10^3) = \underline{\textbf{1.152 watts}}$$

Chapter 4, Problem 72.

(a) For the circuit in Fig. 4.138, obtain the Thevenin equivalent at terminals ***a-b***.
(b) Calculate the current in $R_L = 8\Omega$.
(c) Find R_L for maximum power deliverable to R_L.
(d) Determine that maximum power.

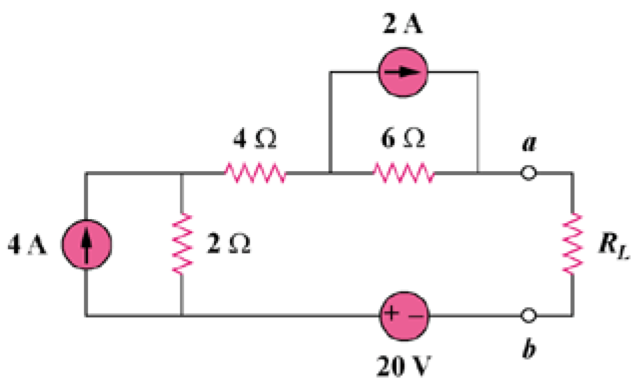


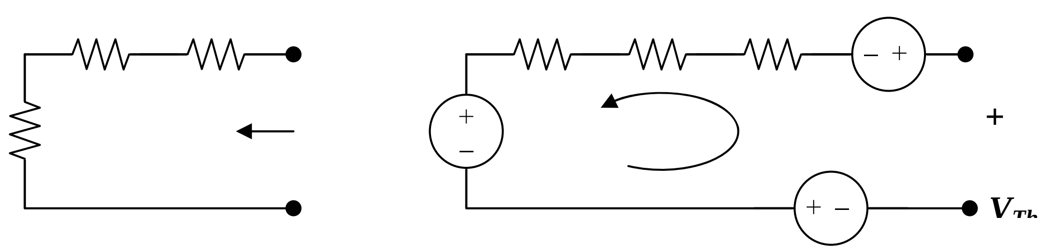
Figure 4.138

Chapter 4, Solution 72.

(a) R_{Th} and V_{Th} are calculated using the circuits shown in Fig. (a) and (b) respectively.

From Fig. (a), $R_{Th} = 2 + 4 + 6 = \underline{\textbf{12 ohms}}$

From Fig. (b), $-V_{Th} + 12 + 8 + 20 = 0$, or $V_{Th} = \underline{\textbf{40 V}}$



(b) $i = V_{Th}/(R_{Th} + R) = 40/(12 + 8) = \underline{\textbf{2A}}$

(c) For maximum power transfer, $R_L = R_{Th} = \underline{\textbf{12 ohms}}$

(d) $p = V_{Th}^2/(4R_{Th}) = (40)^2/(4x12) = \underline{\textbf{33.33 watts}}$.

Chapter 4, Problem 73.

Determine the maximum power that can be delivered to the variable resistor *R* in the circuit of Fig. 4.139.

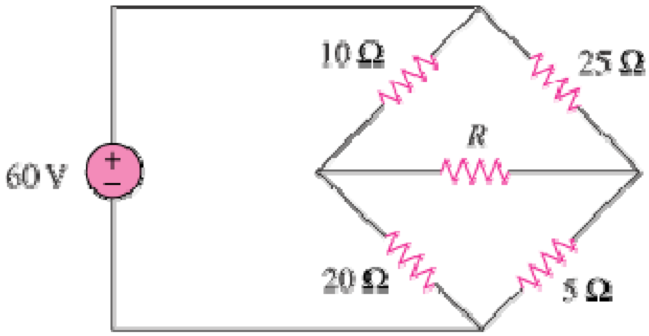
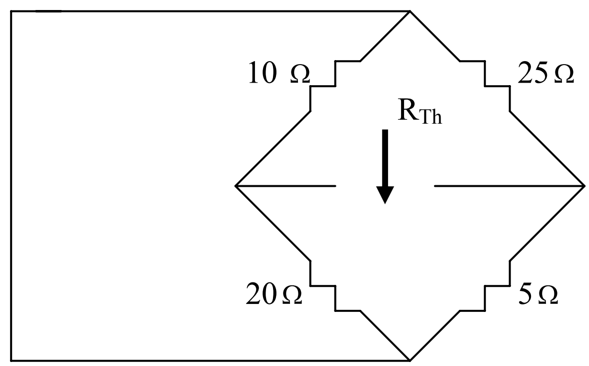


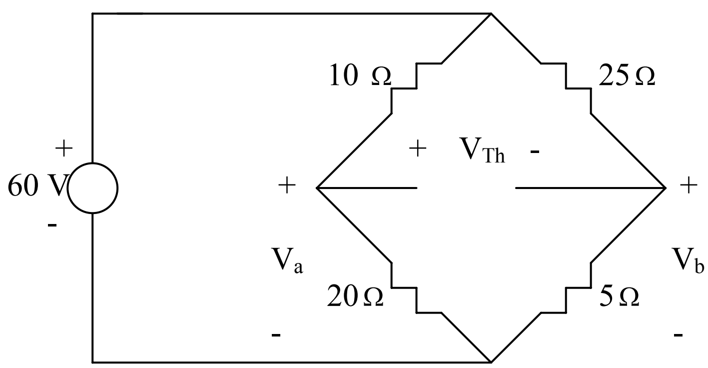
Figure 4.139

Chapter 4, Solution 73

Find the Thevenin's equivalent circuit across the terminals of R.



$$R_{Th} = 10 // 20 + 25 // 5 = 325 / 30 = 10.833\Omega$$



$$V_a = \frac{20}{30}(60) = 40, \qquad V_b = \frac{5}{30}(60) = 10$$

$$-V_a + V_{Th} + V_b = 0 \quad \longrightarrow \quad V_{Th} = V_a - V_b = 40 - 10 = 30 \text{ V}$$

$$p_{\max} = \frac{V_{Th}^{\;2}}{4R_{Th}} = \frac{30^2}{4x10.833} = \underline{20.77 \text{ W}}$$

Chapter 4, Problem 74.

For the bridge circuit shown in Fig. 4.140, find the load $\boldsymbol{R_L}$ for maximum power transfer and the maximum power absorbed by the load.

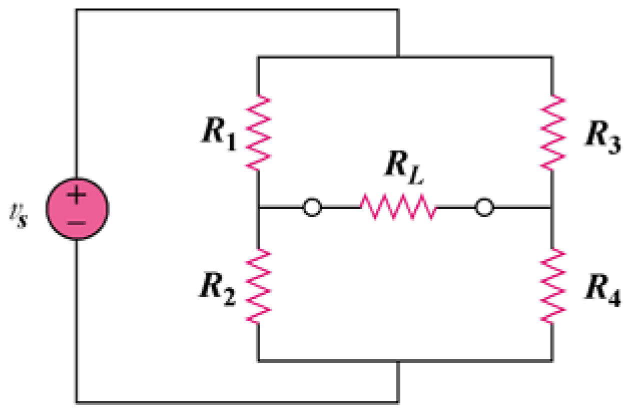


Figure 4.140

Chapter 4, Solution 74.

When R_L is removed and V_s is short-circuited,

$$R_{Th} = R_1||R_2 + R_3||R_4 = [R_1 R_2/(R_1 + R_2)] + [R_3 R_4/(R_3 + R_4)]$$

$$R_L = R_{Th} = \underline{\mathbf{(R_1 R_2 R_3 + R_1 R_2 R_4 + R_1 R_3 R_4 + R_2 R_3 R_4)/[(R_1 + R_2)(R_3 + R_4)]}}$$

When R_L is removed and we apply the voltage division principle,

$$V_{oc} = V_{Th} = v_{R2} - v_{R4}$$

$$= ([R_2/(R_1 + R_2)] - [R_4/(R_3 + R_4)])V_s = \{[(R_2R_3) - (R_1R_4)]/[(R_1 + R_2)(R_3 + R_4)]\}V_s$$

$$p_{max} = V_{Th}^2/(4R_{Th})$$

$$= \{[(R_2R_3) - (R_1R_4)]^2/[(R_1 + R_2)(R_3 + R_4)]^2\}V_s^2[(R_1 + R_2)(R_3 + R_4)]/[4(a)]$$

$$\text{where } a = (R_1 R_2 R_3 + R_1 R_2 R_4 + R_1 R_3 R_4 + R_2 R_3 R_4)$$

$$p_{max} =$$

$$\mathbf{[(R_2R_3) - (R_1R_4)]^2V_s^2/[4(R_1 + R_2)(R_3 + R_4) (R_1 R_2 R_3 + R_1 R_2 R_4 + R_1 R_3 R_4 + R_2 R_3 R_4)]}$$

Chapter 4, Problem 75.

For the circuit in Fig. 4.141, determine the value of ***R*** such that the maximum power delivered to the load is 3 mW.

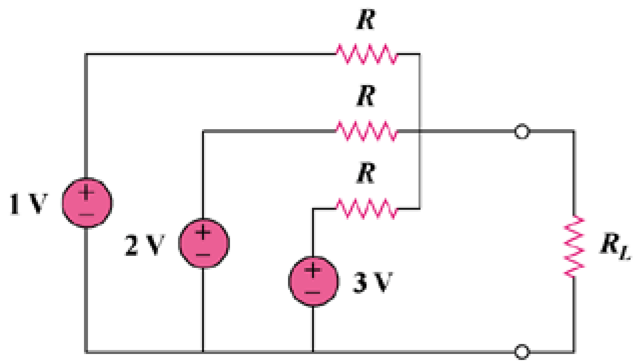
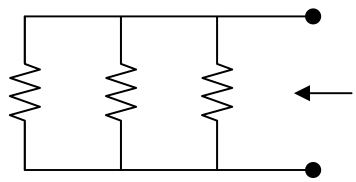
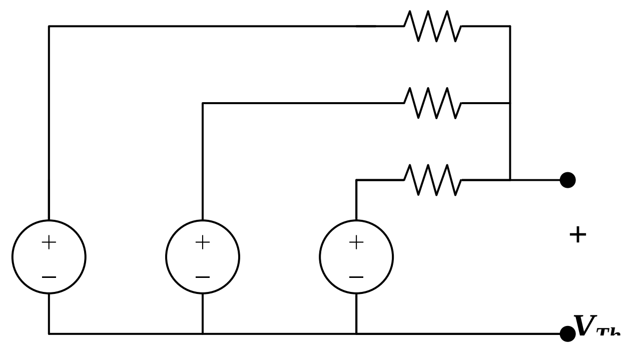


Figure 4.141

Chapter 4, Solution 75.

We need to first find R_{Th} and V_{Th}.





Consider the circuit in Fig. (a).

$$(1/R_{Th}) = (1/R) + (1/R) + (1/R) = 3/R$$

$$R_{Th} = R/3$$

From the circuit in Fig. (b),

$$((1 - v_o)/R) + ((2 - v_o)/R) + ((3 - v_o)/R) = 0$$

$$v_o = 2 = V_{Th}$$

For maximum power transfer,

$$R_L = R_{Th} = R/3$$

$$P_{max} = [(V_{Th})^2/(4R_{Th})] = 3 \text{ mW}$$

$$R_{Th} = [(V_{Th})^2/(4P_{max})] = 4/(4xP_{max}) = 1/P_{max} = R/3$$

$$R = 3/(3x10^{-3}) = \underline{\textbf{1 k ohms}}$$

Chapter 4, Problem 76.

Solve Prob. 4.34 using *PSpice*.

Chapter 4, Problem 34**.**

Find the Thevenin equivalent at terminals ***a-b*** of the circuit in Fig. 4.98.

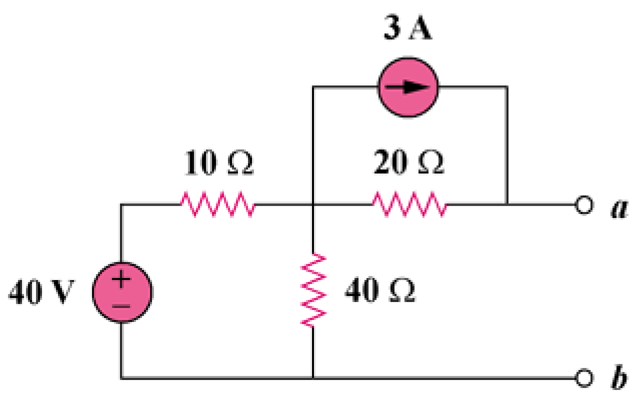


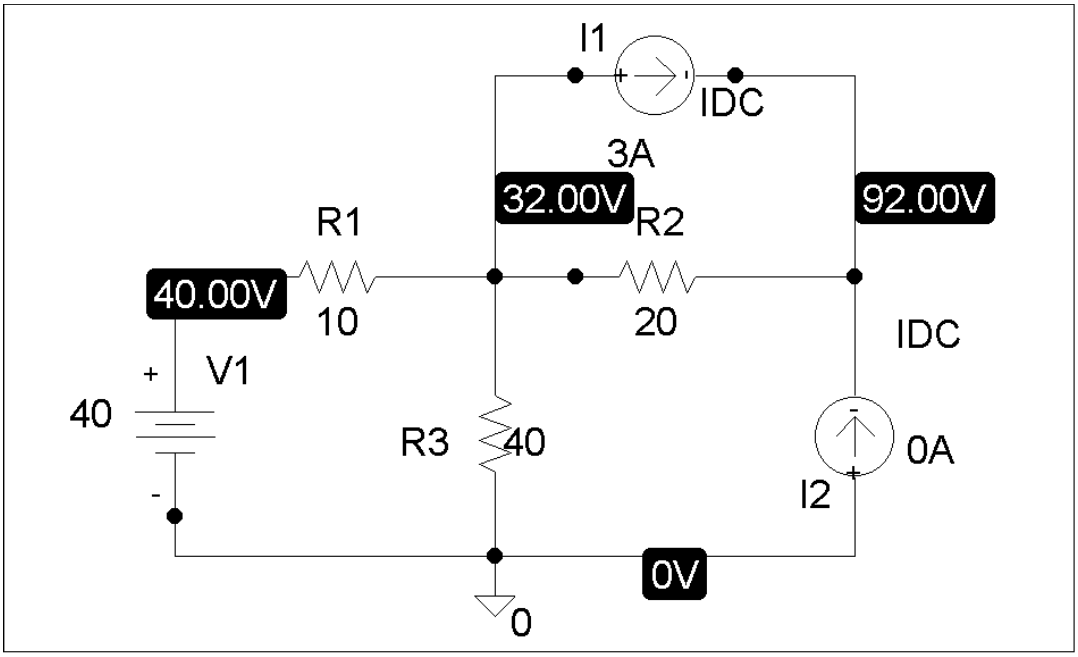
Figure 4.98

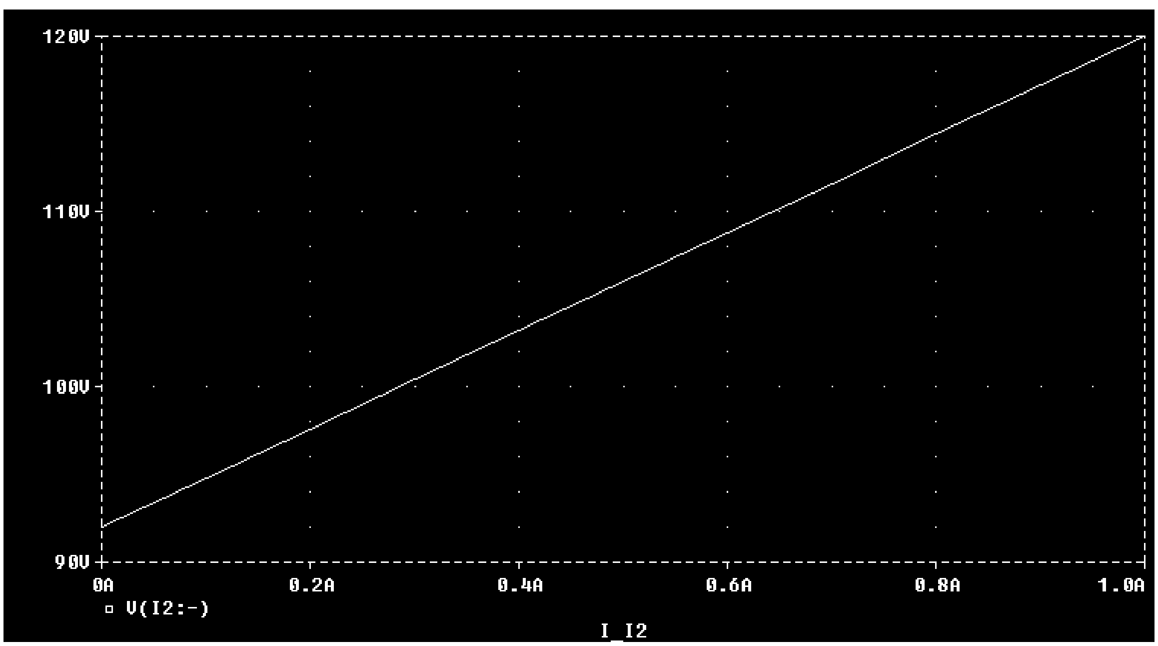
Chapter 4, Solution 76.

Follow the steps in Example 4.14. The schematic and the output plots are shown below. From the plot, we obtain,

$$V = \underline{\mathbf{92\ V}}\ [i = 0, \text{voltage axis intercept}]$$

$$R = \text{Slope} = (120 - 92)/1 = \underline{\mathbf{28\ ohms}}$$





Chapter 4, Problem 77.

Solve Prob. 4.44 using *PSpice.*

Chapter 4, Problem 44.
For the circuit in Fig. 4.111, obtain the Thevenin equivalent as seen from terminals
(b) ***a-b*** (b) ***b-c***

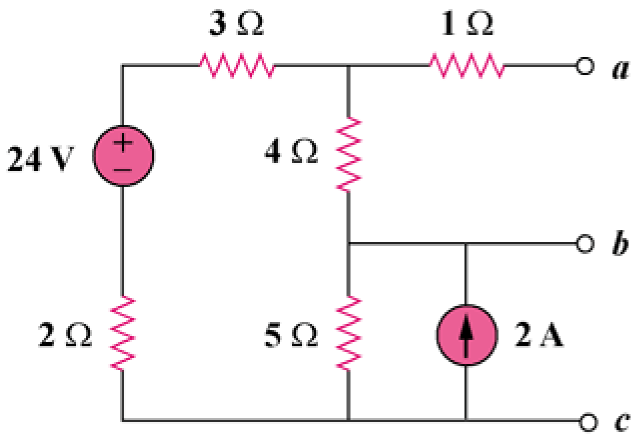
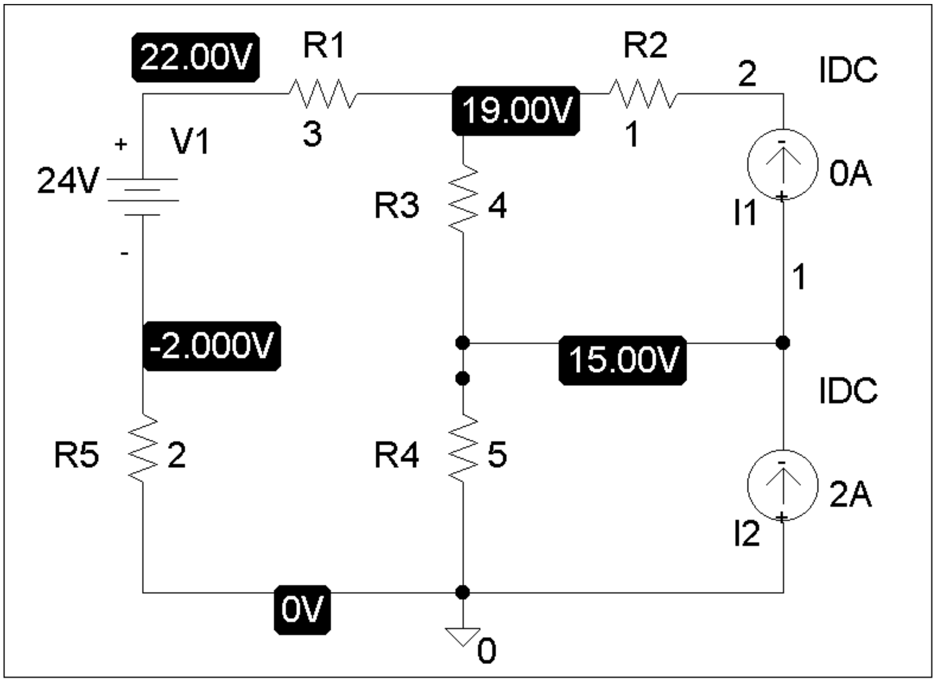


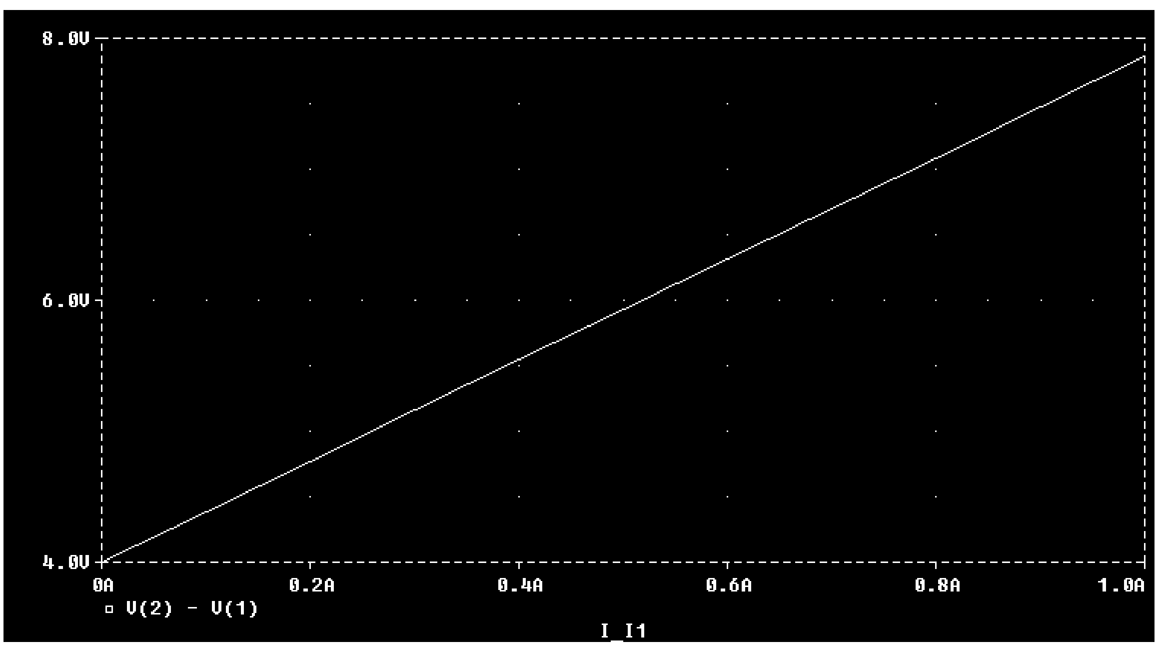
Figure 4.111

Chapter 4, Solution 77.

(a) The schematic is shown below. We perform a dc sweep on a current source, I1, connected between terminals a and b. We label the top and bottom of source I1 as 2 and 1 respectively. We plot V(2) – V(1) as shown.

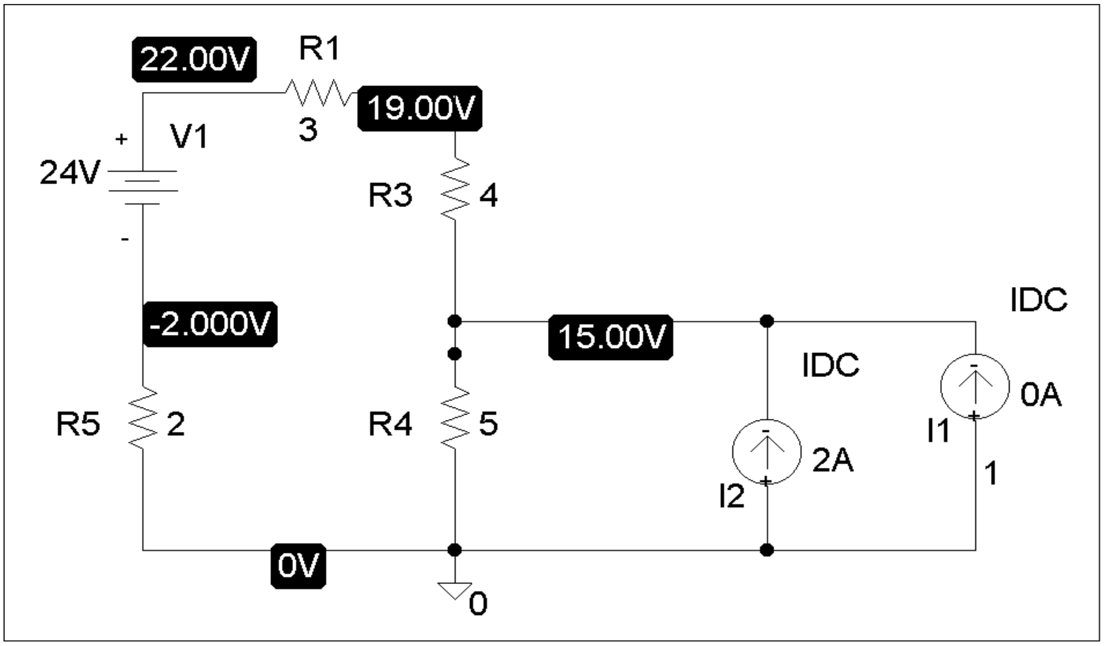
V_{Th} = **<u>4 V</u>** [zero intercept]
R_{Th} = (7.8 – 4)/1 = **<u>3.8 ohms</u>**

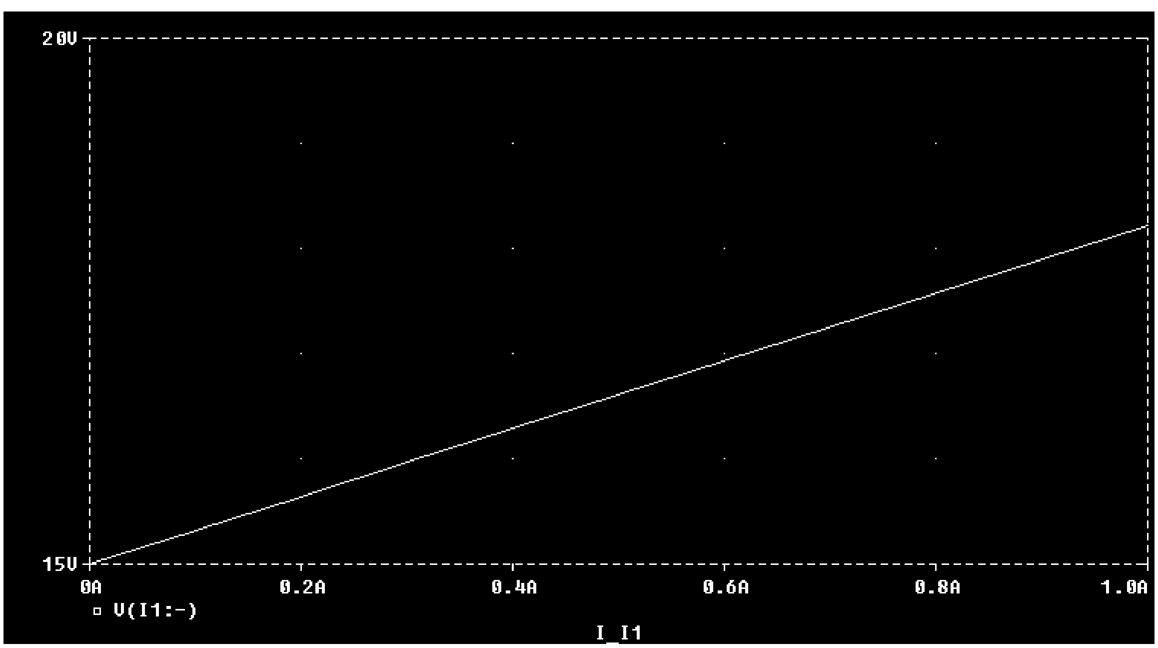




(b) Everything remains the same as in part (a) except that the current source, I1, is connected between terminals b and c as shown below. We perform a dc sweep on I1 and obtain the plot shown below. From the plot, we obtain,

$$V = \underline{\mathbf{15\ V}} \text{ [zero intercept]}$$
$$R = (18.2 - 15)/1 = \underline{\mathbf{3.2\ ohms}}$$





Chapter 4, Problem 78.

Use *PSpice* to solve Prob. 4.52.

Chapter 4, Problem 52**.**

For the transistor model in Fig. 4.111, obtain the Thevenin equivalent at terminals ***a***-***b***.

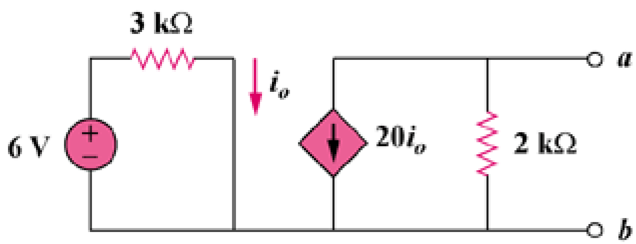


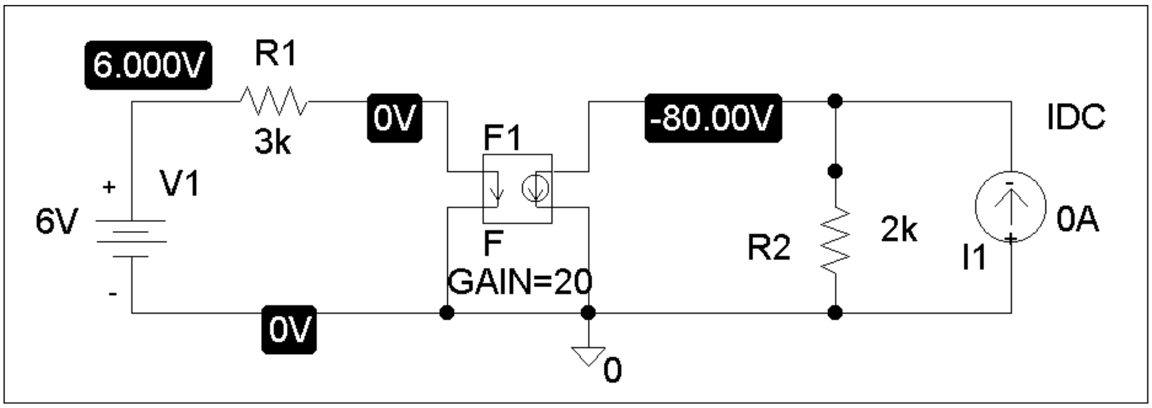
Figure 4.111

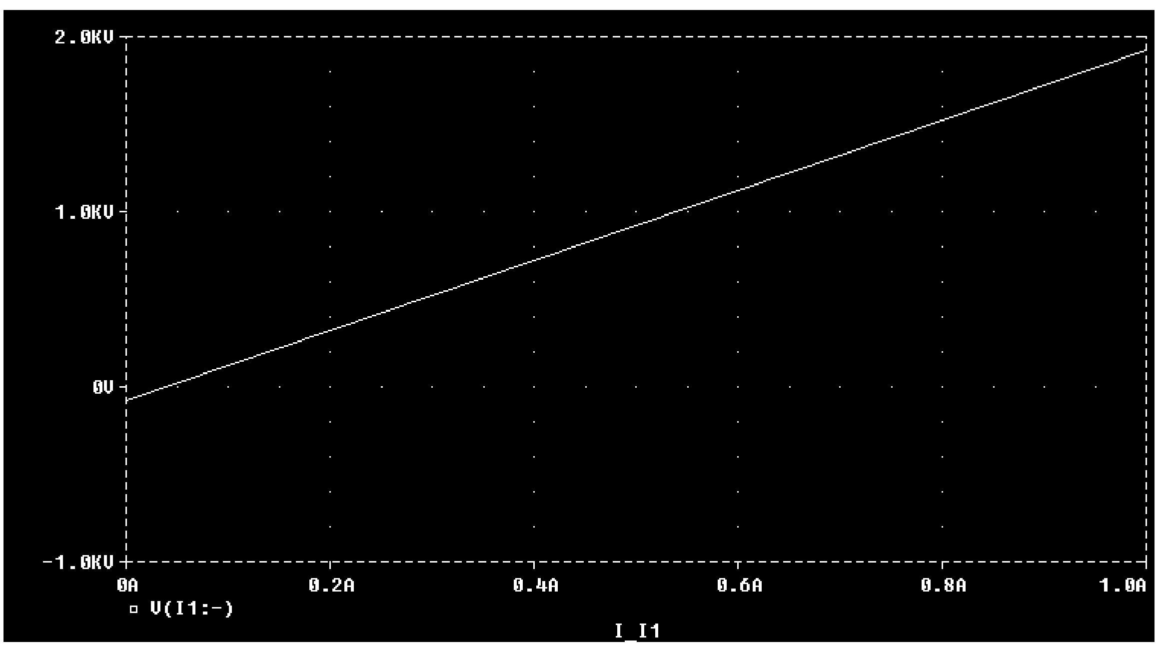
Chapter 4, Solution 78.

The schematic is shown below. We perform a dc sweep on the current source, I1, connected between terminals a and b. The plot is shown. From the plot we obtain,

$$V_{Th} = \underline{\mathbf{-80\ V}} \text{ [zero intercept]}$$

$$R_{Th} = (1920 - (-80))/1 = \underline{\mathbf{2\ k\ ohms}}$$





Chapter 4, Problem 79.

Obtain the Thevenin equivalent of the circuit in Fig. 4.123 using *PSpice*.

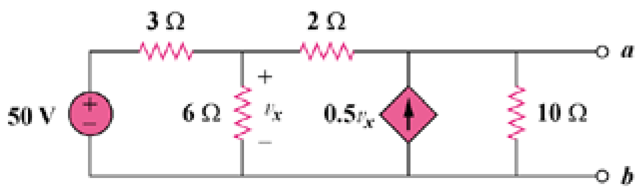


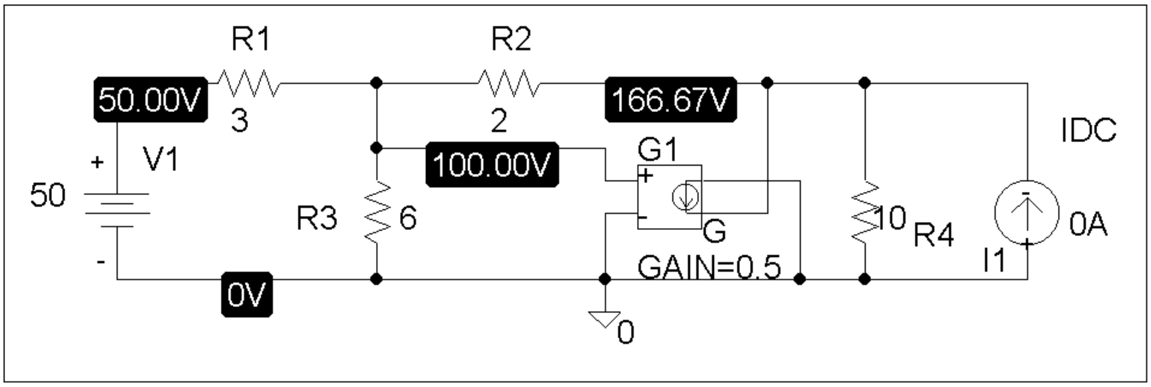
Figure 4.123

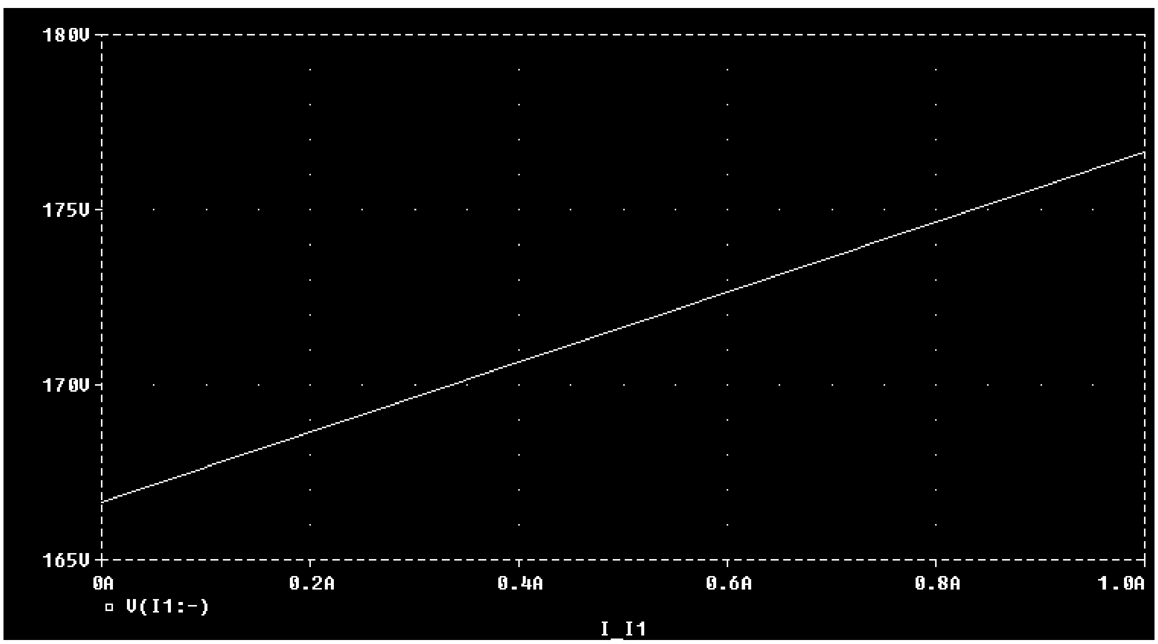
Chapter 4, Solution 79.

After drawing and saving the schematic as shown below, we perform a dc sweep on I1 connected across a and b. The plot is shown. From the plot, we get,

$$V = \underline{\mathbf{167\ V}} \quad \text{[zero intercept]}$$

$$R = (177 - 167)/1 = \underline{\mathbf{10\ ohms}}$$





Chapter 4, Problem 80.

Use *PSpice* to find the Thevenin equivalent circuit at terminals ***a-b*** of the circuit in Fig. 4.125.

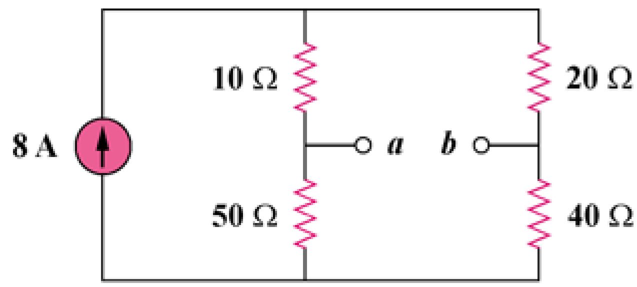


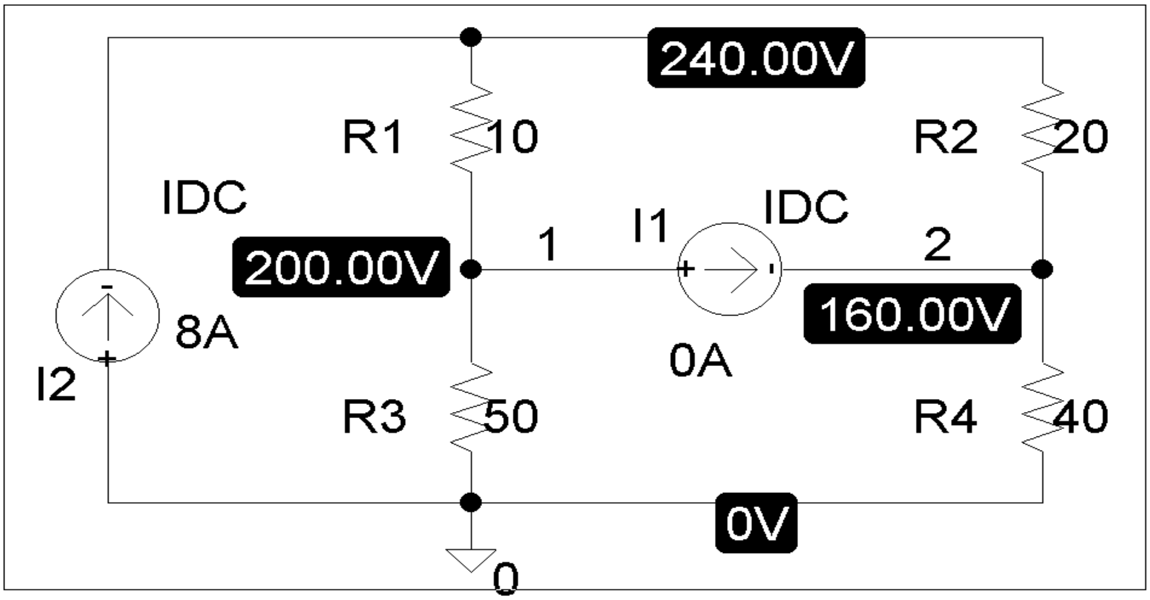
Figure 4.125

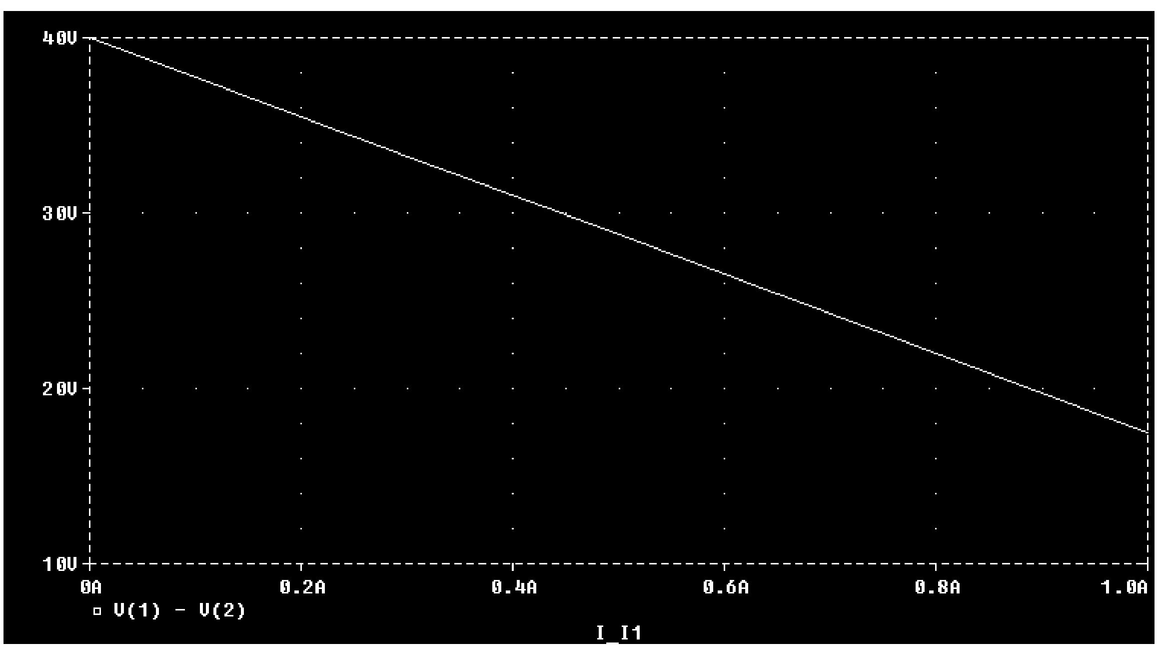
Chapter 4, Solution 80.

The schematic in shown below. We label nodes a and b as 1 and 2 respectively. We perform dc sweep on I1. In the Trace/Add menu, type v(1) – v(2) which will result in the plot below. From the plot,

$$V_{Th} = \underline{\mathbf{40\ V}} \quad \text{[zero intercept]}$$

$$R_{Th} = (40 - 17.5)/1 = \underline{\mathbf{22.5\ ohms}} \quad \text{[slope]}$$





Chapter 4, Problem 81.

For the circuit in Fig. 4.126, use *PSpice* to find the Thevenin equivalent at terminals ***a-b***.

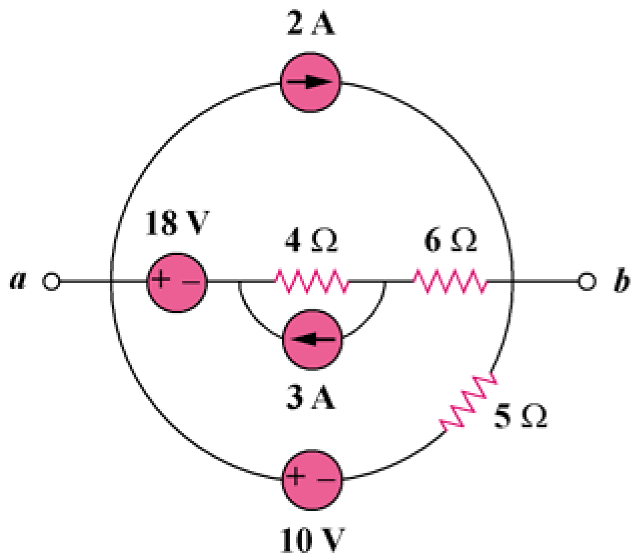


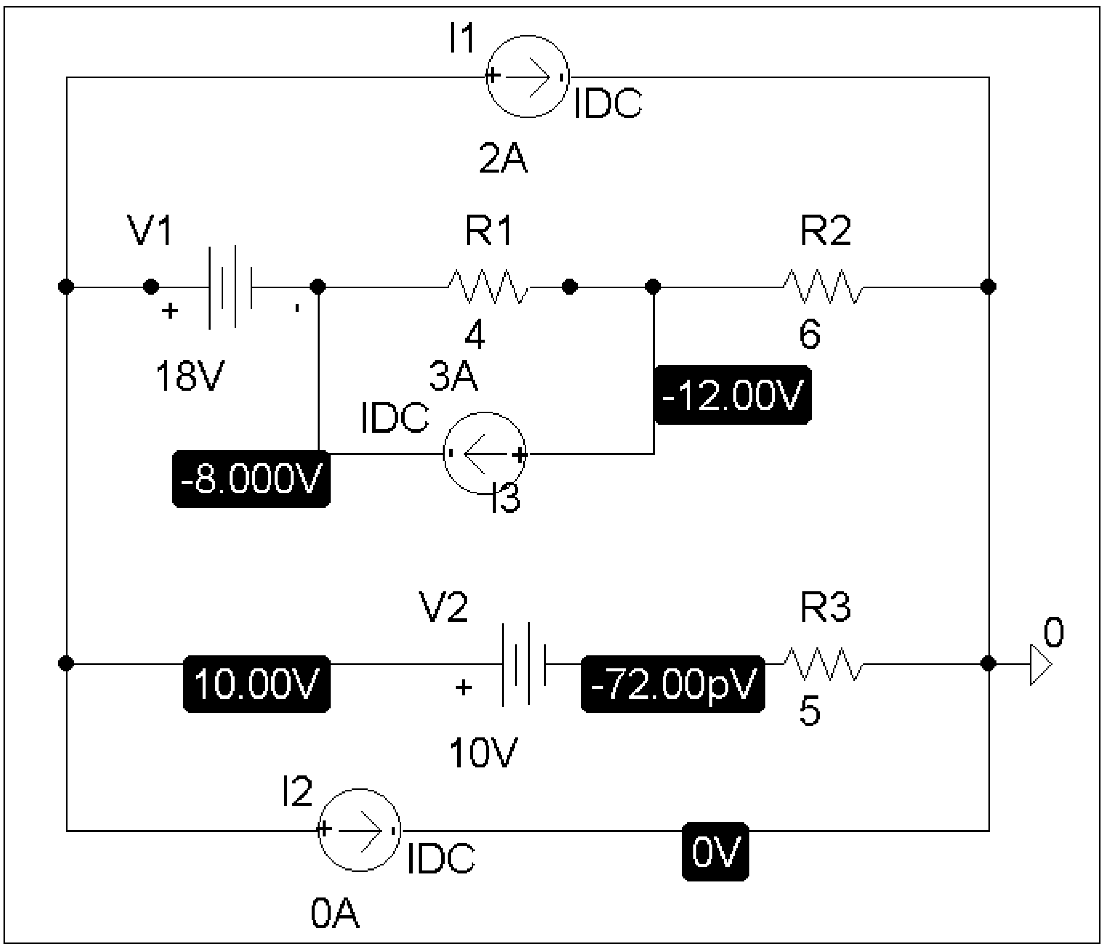
Figure 4.126

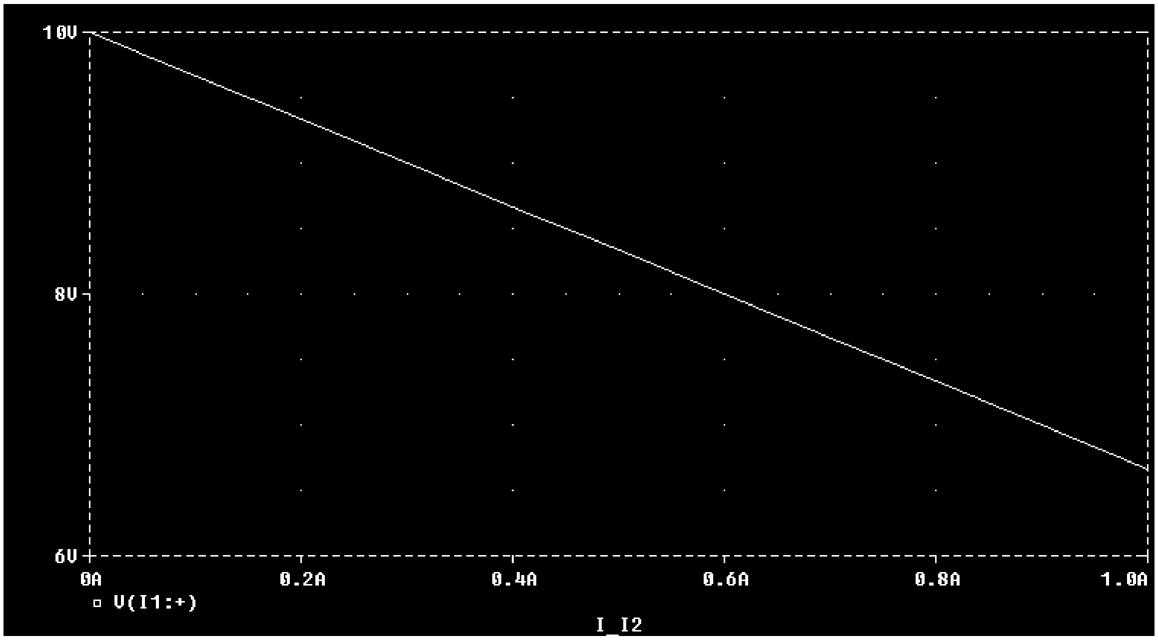
Chapter 4, Solution 81.

The schematic is shown below. We perform a dc sweep on the current source, I2, connected between terminals a and b. The plot of the voltage across I2 is shown below. From the plot,

$$V_{Th} = \underline{\mathbf{10\ V}} \quad \text{[zero intercept]}$$

R_{Th} = (10 – 6.7)/1 = **<u>3.3 ohms</u>**. Note that this is in good agreement with the exact value of 3.333 ohms.




10V
8V
6V
0A
0.2A
0.4A
0.6A
0.8A
1.0A
V(I1:+)
I_I2

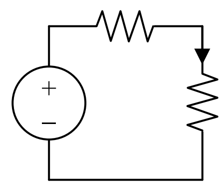
Chapter 4, Problem 82.

A battery has a short-circuit current of 20 A and an open-circuit voltage of 12 V. If the battery is connected to an electric bulb of resistance 2 Ω, calculate the power dissipated by the bulb.

Chapter 4, Solution 82.

$V_{Th} = V_{oc} = 12$ V, $I_{sc} = 20$ A

$$R_{Th} = V_{oc}/I_{sc} = 12/20 = 0.6 \text{ ohm.}$$



$$i = 12/2.6\,, \quad p = i^2R = (12/2.6)^2(2) = \underline{\mathbf{42.6\ watts}}$$

Chapter 4, Problem 83.

The following results were obtained from measurements taken between the two terminals of a resistive network.

Terminal Voltage	12 V	0 V
Terminal Current	0 V	1.5A

Find the Thevenin equivalent of the network.

Chapter 4, Solution 83.

$V_{Th} = V_{oc} = 12$ V, $I_{sc} = I_N = 1.5$ A

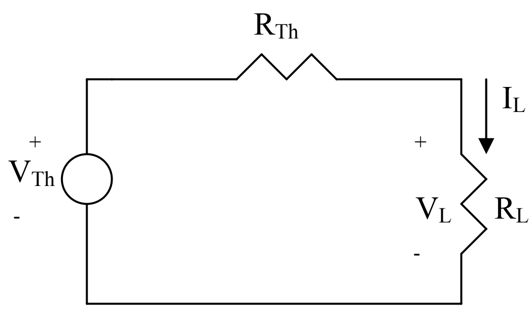
$$R_{Th} = V_{Th}/I_N = 8 \text{ ohms}, \; V_{Th} = \underline{\mathbf{12\ V}}, \; R_{Th} = \underline{\mathbf{8\ ohms}}$$

Chapter 4, Problem 84.

When connected to a 4-Ω resistor, a battery has a terminal voltage of 10.8 V but produces 12 V on open circuit. Determine the Thèvenin equivalent circuit for the battery.

Chapter 4, Solution 84

Let the equivalent circuit of the battery terminated by a load be as shown below.



For open circuit,

$$R_L = \infty, \qquad \longrightarrow \qquad V_{Th} = V_{oc} = V_L = \underline{10.8\text{ V}}$$

When $R_L = 4$ ohm, V_L=10.5,

$$I_L = \frac{V_L}{R_L} = 10.8/4 = 2.7$$

But

$$V_{Th} = V_L + I_L R_{Th} \qquad \longrightarrow \qquad R_{Th} = \frac{V_{Th} - V_L}{I_L} = \frac{12 - 10.8}{2.7} = \underline{0.4444\Omega}$$

Chapter 4, Problem 85.

The Thèvenin equivalent at terminals *a-b* of the linear network shown in Fig. 4.142 is to be determined by measurement. When a 10-kΩ resistor is connected to terminals *a-b*, the voltage V_{ab} is measured as 6 V. When a 30-kΩ resistor is connected to the terminals, V_{ab} is measured as 12 V. Determine: (a) the Thèvenin equivalent at terminals *a-b*, (b) V_{ab} when a 20-kΩ resistor is connected to terminals *a-b*.

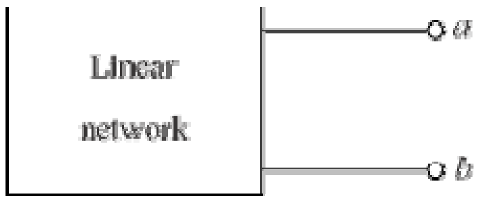
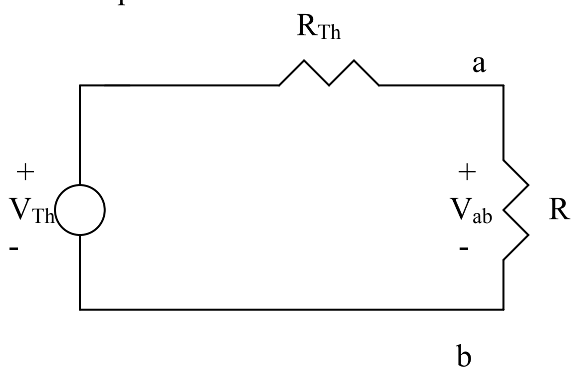


Figure 4.142

Chapter 4, Solution 85

(a) Consider the equivalent circuit terminated with R as shown below.



$$V_{ab} = \frac{R}{R+R_{Th}}V_{Th} \longrightarrow 6 = \frac{10}{10+R_{Th}}V_{Th}$$

or

$$60 + 6R_{Th} = 10V_{Th} \qquad (1)$$

where R_{Th} is in k-ohm.

Similarly,

$$12 = \frac{30}{30+R_{Th}}V_{Th} \longrightarrow 360 + 12R_{Th} = 30V_{Th} \qquad (2)$$

Solving (1) and (2) leads to

$$\underline{V_{Th} = 24\text{ V},\ R_{Th} = 30k\Omega}$$

(b) $V_{ab} = \frac{20}{20+30}(24) = \underline{9.6\text{ V}}$

Chapter 4, Problem 86.

A black box with a circuit in it is connected to a variable resistor. An ideal ammeter (with zero resistance) and an ideal voltmeter (with infinite resistance) are used to measure current and voltage as shown in Fig. 4.143. The results are shown in the table below.

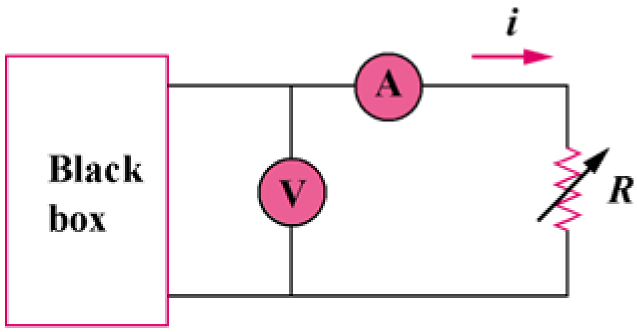


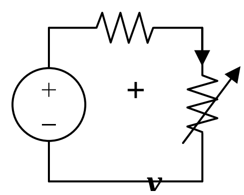
Figure 4.143

(a) Find $\boldsymbol{i}$ when $\boldsymbol{R} = 4\ \Omega$.
(b) Determine the maximum power from the box.

$\boldsymbol{R}(\Omega)$	$\boldsymbol{V}$(V)	$\boldsymbol{i}$(A)
2	3	1.5
8	8	1.0
14	10.5	0.75

Chapter 4, Solution 86.

We replace the box with the Thevenin equivalent.



$$V_{Th} = v + iR_{Th}$$

When $i = 1.5$, $v = 3$, which implies that $V_{Th} = 3 + 1.5R_{Th}$ (1)

When $i = 1$, $v = 8$, which implies that $V_{Th} = 8 + 1xR_{Th}$ (2)

From (1) and (2), $R_{Th} = 10$ ohms and $V_{Th} = 18$ V.

(a) When $R = 4$, $i = V_{Th}/(R + R_{Th}) = 18/(4 + 10) =$ **1.2857 A**

(b) For maximum power, $R = R_{TH}$

$$Pmax = (V_{Th})^2/4R_{Th} = 18^2/(4x10) = \underline{\textbf{8.1 watts}}$$

Chapter 4, Problem 87.

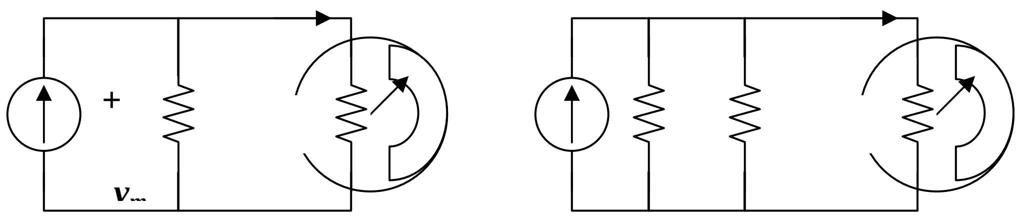
A transducer is modeled with a current source $\boldsymbol{I_s}$ and a parallel resistance $\boldsymbol{R_s}$. The current at the terminals of the source is measured to be 9.975 mA when an ammeter with an internal resistance of 20 Ω is used.

(a) If adding a 2-kΩ resistor across the source terminals causes the ammeter reading to fall to 9.876 mA, calculate $\boldsymbol{I_s}$ and $\boldsymbol{R_s}$.

(b) What will the ammeter reading be if the resistance between the source terminals is changed to 4 kΩ?

Chapter 4, Solution 87.

(a)



From Fig. (a),

$$v_m = R_m i_m = 9.975 \text{ mA x } 20 = 0.1995 \text{ V}$$

$$I_s = 9.975 \text{ mA} + (0.1995/R_s) \qquad (1)$$

From Fig. (b),

$$v_m = R_m i_m = 20x9.876 = 0.19752 \text{ V}$$

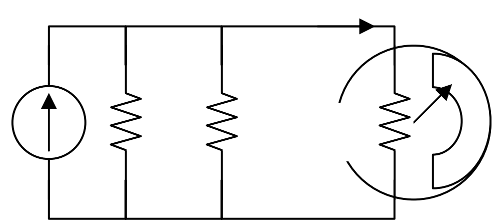
$$I_s = 9.876 \text{ mA} + (0.19752/2k) + (0.19752/R_s)$$

$$= 9.975 \text{ mA} + (0.19752/R_s) \qquad (2)$$

Solving (1) and (2) gives,

$$R_s = \underline{\textbf{8 k ohms}}, \qquad I_s = \underline{\textbf{10 mA}}$$

(b)



$$8k||4k = 2.667 \text{ k ohms}$$

$$i_m' = [2667/(2667 + 20)](10 \text{ mA}) = \underline{\textbf{9.926 mA}}$$

Chapter 4, Problem 88.

Consider the circuit in Fig. 4.144. An ammeter with internal resistance R_i is inserted between A and B to measure I_o. Determine the reading of the ammeter if: (a) $R_i = 500\ \Omega$, (b) $R_i = 0\ \Omega$. (*Hint*: Find the Thèvenin equivalent circuit at terminals *A*-*B*.)

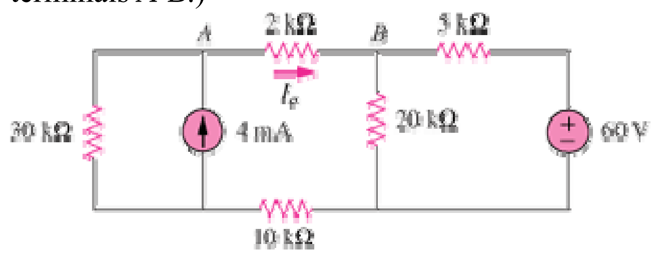
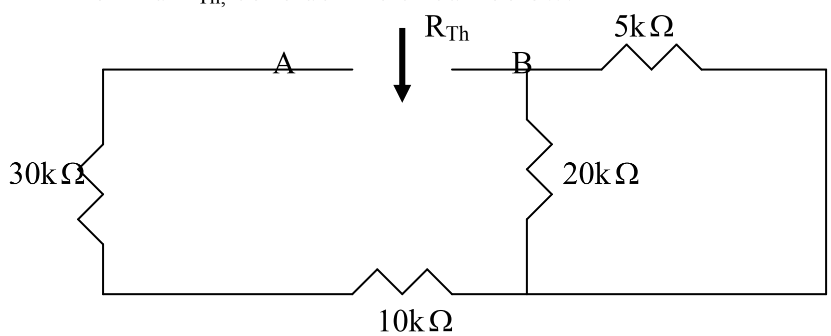


Figure 4.144

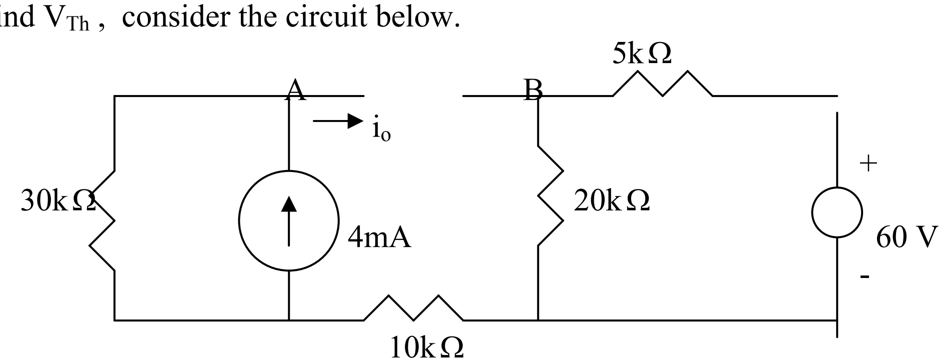
Chapter 4, Solution 88

To find R_{Th}, consider the circuit below.



$$R_{Th} = 30 + 10 + 20 // 5 = 44k\Omega$$

To find V_{Th}, consider the circuit below.



$$V_A = 30x4 = 120, \qquad V_B = \frac{20}{25}(60) = 48, \qquad V_{Th} = V_A - V_B = 72\text{ V}$$

Chapter 4, Problem 89.

Consider the circuit in Fig. 4.145. (a) Replace the resistor R_L by a zero resistance ammeter and determine the ammeter reading. (b) To verify the reciprocity theorem, interchange the ammeter and the 12-V source and determine the ammeter reading again.

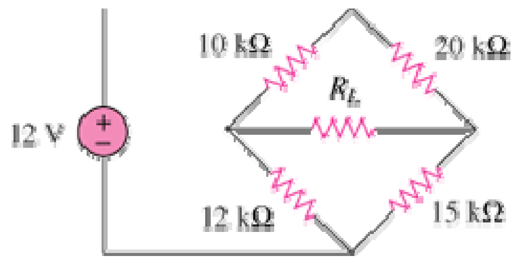
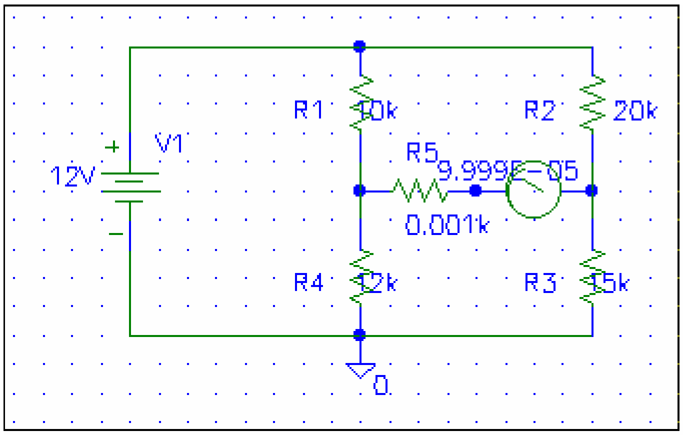


Figure 4.145

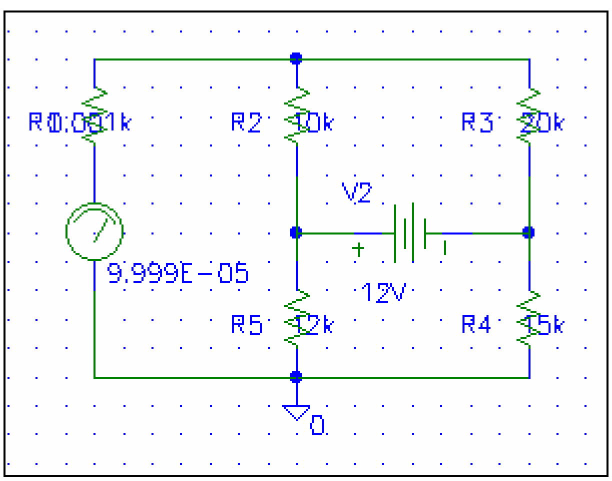
Chapter 4, Solution 89

It is easy to solve this problem using Pspice.

(a) The schematic is shown below. We insert IPROBE to measure the desired ammeter reading. We insert a very small resistance in series IPROBE to avoid problem. After the circuit is saved and simulated, the current is displaced on IPROBE as $99.99\mu\text{A}$.



(b) By interchanging the ammeter and the 12-V voltage source, the schematic is shown below. We obtain exactly the same result as in part (a).



Chapter 4, Problem 90.

The Wheatstone bridge circuit shown in Fig. 4.146 is used to measure the resistance of a strain gauge. The adjustable resistor has a linear taper with a maximum value of 100 Ω. If the resistance of the strain gauge is found to be 42.6 Ω, what fraction of the full slider travel is the slider when the bridge is balanced?

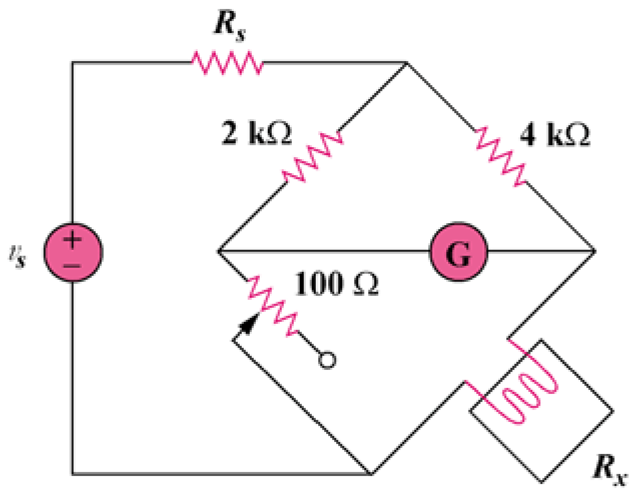


Figure 4.146

Chapter 4, Solution 90.

$R_x = (R_3/R_1)R_2 = (4/2)R_2 = 42.6, \ R_2 = 21.3$

which is (21.3ohms/100ohms)% = **21.3%**

Chapter 4, Problem 91.

(a) In the Wheatstone bridge circuit of Fig. 4.147 select the values of $\boldsymbol{R_1}$ and $\boldsymbol{R_3}$ such that the bridge can measure $\boldsymbol{R_x}$ in the reange of 0-10 Ω.

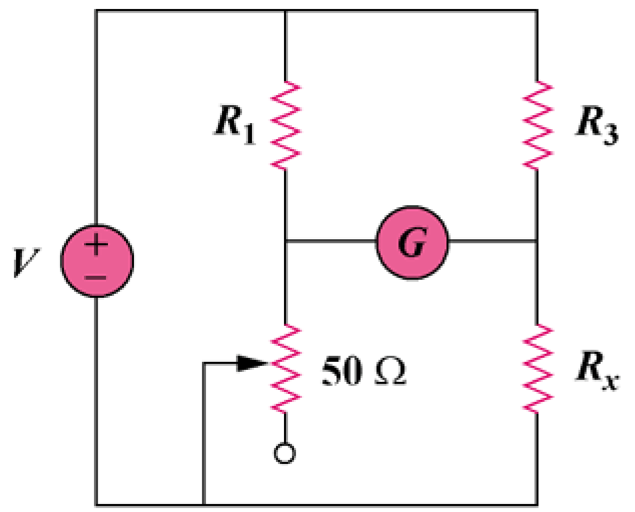


Figure 4.147

(b) Repeat for the range of 0-100 Ω.

Chapter 4, Solution 91.

$R_x = (R_3/R_1)R_2$

(a) Since $0 < R_2 < 50$ ohms, to make $0 < R_x < 10$ ohms requires that when $R_2 = 50$ ohms, $R_x = 10$ ohms.

$$10 = (R_3/R_1)50 \quad \text{or} \quad R_3 = R_1/5$$

so we select R_1 = **<u>100 ohms</u>** and R_3 = **<u>20 ohms</u>**

(b) For $0 < R_x < 100$ ohms

$$100 = (R_3/R_1)50, \quad \text{or} \quad R_3 = 2R_1$$

So we can select R_1 = **<u>100 ohms</u>** and R_3 = **<u>200 ohms</u>**

Chapter 4, Problem 92.

Consider the bridge circuit of Fig. 4.148. Is the bridge balanced? If the 10 Ω resistor is replaced by an 18-kΩ resistor, what resistor connected between terminals ***a*-*b*** absorbs the maximum power? What is this power?.

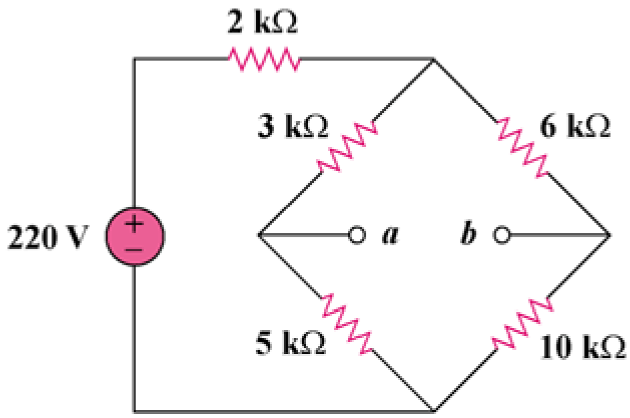
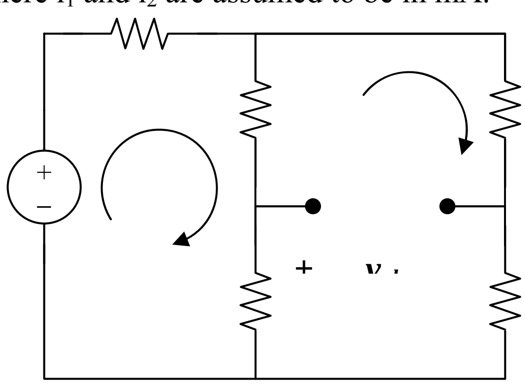


Figure 4.148

Chapter 4, Solution 92.

For a balanced bridge, $v_{ab} = 0$. We can use mesh analysis to find v_{ab}. Consider the circuit in Fig. (a), where i_1 and i_2 are assumed to be in mA.



$$220 = 2i_1 + 8(i_1 - i_2) \text{ or } 220 = 10i_1 - 8i_2 \quad (1)$$

$$0 = 24i_2 - 8i_1 \text{ or } i_2 = (1/3)i_1 \quad (2)$$

From (1) and (2),

$$i_1 = 30 \text{ mA and } i_2 = 10 \text{ mA}$$

Applying KVL to loop 0ab0 gives

$$5(i_2 - i_1) + v_{ab} + 10i_2 = 0 \text{ V}$$

Since $v_{ab} = 0$, the bridge is balanced.

When the 10 k ohm resistor is replaced by the 18 k ohm resistor, the gridge becomes unbalanced. (1) remains the same but (2) becomes

$$0 = 32i_2 - 8i_1, \text{ or } i_2 = (1/4)i_1 \qquad (3)$$

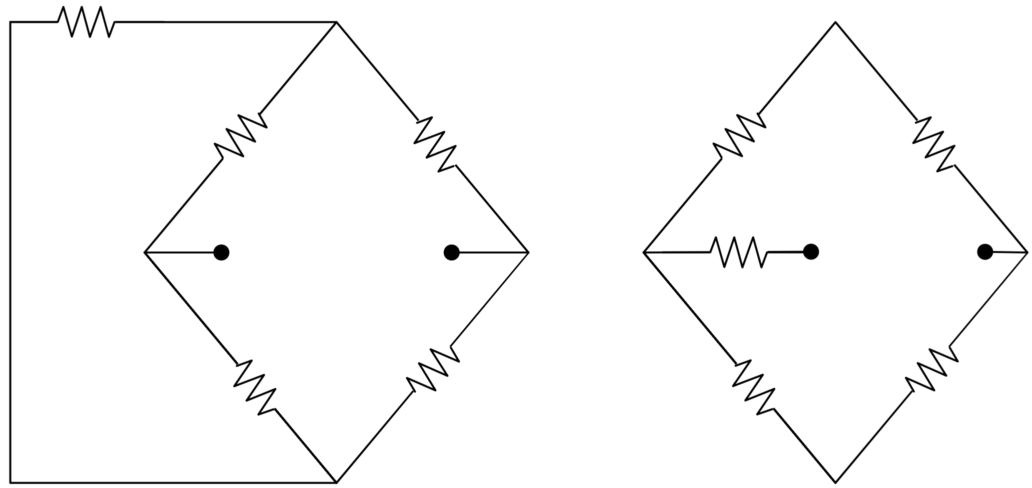
Solving (1) and (3),

$$i_1 = 27.5 \text{ mA}, \; i_2 = 6.875 \text{ mA}$$

$$v_{ab} = 5(i_1 - i_2) - 18i_2 = -20.625 \text{ V}$$

$$V_{Th} = v_{ab} = -20.625 \text{ V}$$

To obtain R_{Th}, we convert the delta connection in Fig. (b) to a wye connection shown in Fig. (c).



$$R_1 = 3x5/(2 + 3 + 5) = 1.5 \text{ k ohms}, \; R_2 = 2x3/10 = 600 \text{ ohms},$$

$$R_3 = 2x5/10 = 1 \text{ k ohm.}$$

$$R_{Th} = R_1 + (R_2 + 6)||(R_3 + 18) = 1.5 + 6.6||9 = 6.398 \text{ k ohms}$$

$$R_L = R_{Th} = \underline{\mathbf{6.398 \text{ k ohms}}}$$

$$P_{max} = (V_{Th})^2/(4R_{Th}) = (20.625)^2/(4x6.398) = \underline{\mathbf{16.622 \text{ mWatts}}}$$

Chapter 4, Problem 93.

The circuit in Fig. 4.149 models a common-emitter transistor amplifier. Find $\boldsymbol{i_x}$ using source transformation.

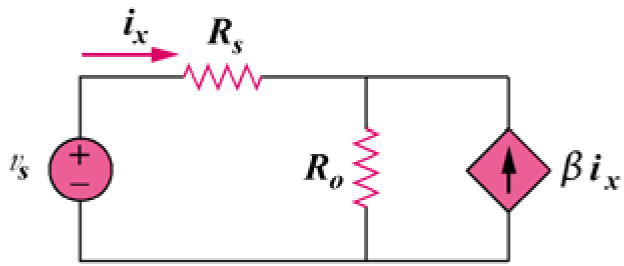
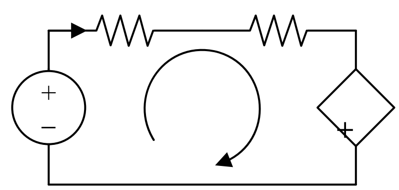


Figure 4.149

Chapter 4, Solution 93.



$$-V_s + (R_s + R_o)i_x + \beta R_o i_x = 0$$

$$i_x = \underline{\mathbf{V_s/(R_s + (1 + \beta)R_o)}}$$

Chapter 4, Problem 94.

An attenuator is an interface circuit that reduces the voltage level without changing the output resistance.

(a) By specifying $\boldsymbol{R_s}$ and $\boldsymbol{R_p}$ of the interface circuit in Fig. 4.150, design an attenuator that will meet the following requirements:

$$\frac{V_o}{V_g} = 0.125, \qquad R_{eq} = R_{\text{Th}} = R_g = 100\Omega$$

(b) Using the interface designed in part (a), calculate the current through a load of $\boldsymbol{R_L}$ = 50 Ω when $\boldsymbol{V_g}$ = 12 V.

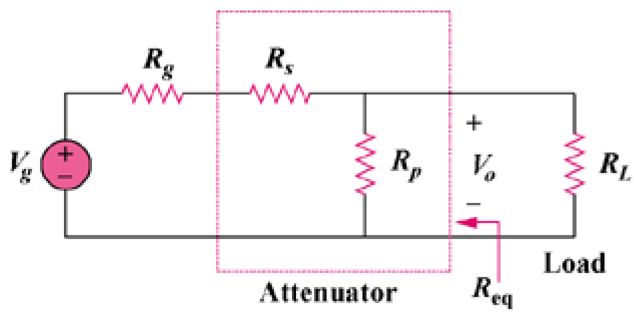


Figure 4.150

Chapter 4, Solution 94.

(a) $$V_o/V_g = R_p/(R_g + R_s + R_p) \qquad (1)$$

$$R_{eq} = R_p||(R_g + R_s) = R_g$$

$$R_g = R_p(R_g + R_s)/(R_p + R_g + R_s)$$

$$R_gR_p + R_g^2 + R_gR_s = R_pR_g + R_pR_s$$

$$R_pR_s = R_g(R_g + R_s) \qquad (2)$$

From (1), $$R_p/\alpha = R_g + R_s + R_p$$

$$R_g + R_s = R_p((1/\alpha) – 1) = R_p(1 - \alpha)/\alpha \qquad (1a)$$

Combining (2) and (1a) gives,

$$R_s = [(1 - \alpha)/\alpha]R_{eq} \qquad (3)$$

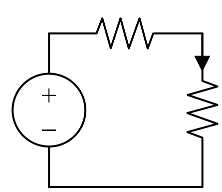
$$= (1 – 0.125)(100)/0.125 = \underline{\textbf{700 ohms}}$$

From (3) and (1a),

$$R_p(1 - \alpha)/\alpha = R_g + [(1 - \alpha)/\alpha]R_g = R_g/\alpha$$

$$R_p = R_g/(1 - \alpha) = 100/(1 – 0.125) = \underline{\textbf{114.29 ohms}}$$

(b)



$$V_{Th} = V_s = 0.125V_g = 1.5 \text{ V}$$

$$R_{Th} = R_g = 100 \text{ ohms}$$

$$I = V_{Th}/(R_{Th} + R_L) = 1.5/150 = \underline{\textbf{10 mA}}$$

Chapter 4, Problem 95.

A dc voltmeter with a sensitivity of 20 kΩ/V is used to find the Thevenin equivalent of a linear network. Readings on two scales are as follows:

(c) 0-10 V scale: 4 V

(d) 0-50 V scale: 5 V

Obtain the Thevenin voltage and the Thevenin resistance of the network.

Chapter 4, Solution 95.

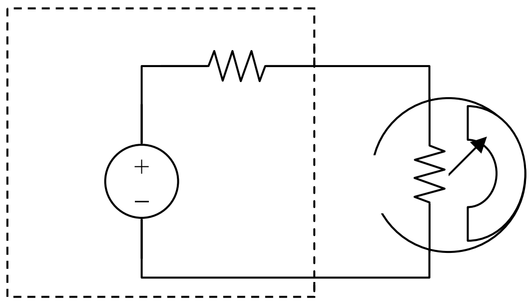
Let 1/sensitivity = 1/(20 k ohms/volt) = 50 μA

For the 0 – 10 V scale,

$$R_m = V_{fs}/I_{fs} = 10/50\ \mu A = 200\ k\ ohms$$

For the 0 – 50 V scale,

$$R_m = 50(20\ k\ ohms/V) = 1\ M\ ohm$$



$$V_{Th} = I(R_{Th} + R_m)$$

(a) A 4V reading corresponds to

$$I = (4/10)I_{fs} = 0.4x50\ \mu A = 20\ \mu A$$

$$V_{Th} = 20\ \mu A\ R_{Th} + 20\ \mu A\ 250\ k\ ohms$$

$$= 4 + 20\ \mu A\ R_{Th} \qquad (1)$$

(b) A 5V reading corresponds to

$$I = (5/50)I_{fs} = 0.1\ x\ 50\ \mu A = 5\ \mu A$$

$$V_{Th} = 5\ \mu A\ x\ R_{Th} + 5\ \mu A\ x\ 1\ M\ ohm$$

$$V_{Th} = 5 + 5\ \mu A\ R_{Th} \qquad (2)$$

From (1) and (2)

$$0 = -1 + 15\ \mu A\ R_{Th} \text{ which leads to } R_{Th} = \underline{\mathbf{66.67\ k\ ohms}}$$

From (1),

$$V_{Th} = 4 + 20x10^{-6}x(1/(15x10^{-6})) = \underline{\mathbf{5.333\ V}}$$

Chapter 4, Problem 96.

A resistance array is connected to a load resistor ***R*** and a 9-V battery as shown in Fig. 4.151.

(e) Find the value of ***R*** such that $V_o = 1.8$ V.

(f) Calculate the value of ***R*** that will draw the maximum current. What is the maximum current?

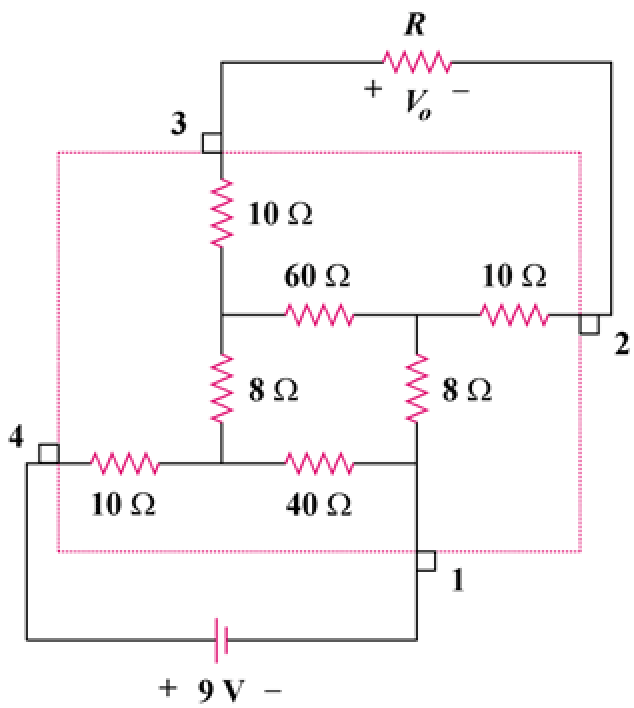
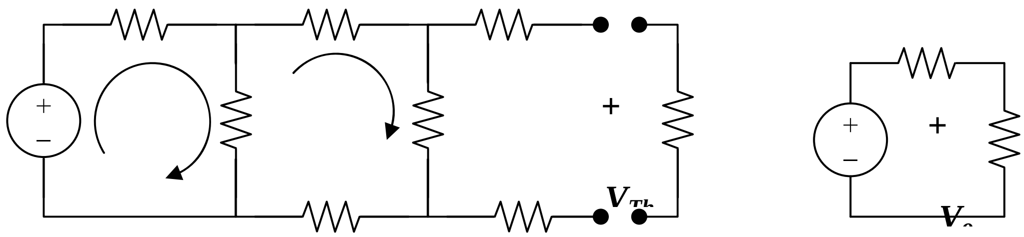


Figure 4.151

Chapter 4, Solution 96.

(a) The resistance network can be redrawn as shown in Fig. (a),



$$R_{Th} = 10 + 10 + 60||(8 + 8 + 10||40) = 20 + 60||24 = 37.14 \text{ ohms}$$

Using mesh analysis,

$$-9 + 50i_1 - 40i_2 = 0 \quad (1)$$
$$116i_2 - 40i_1 = 0 \text{ or } i_1 = 2.9i_2 \quad (2)$$

From (1) and (2), $i_2 = 9/105$

$$V_{Th} = 60i_2 = 5.143 \text{ V}$$

From Fig. (b),

$$V_o = [R/(R + R_{Th})]V_{Th} = 1.8$$

$R/(R + 37.14) = 1.8/5.143$ which leads to R = **20 ohms**

(b) $R = R_{Th} =$ **37.14 ohms**

$I_{max} = V_{Th}/(2R_{Th}) = 5.143/(2x37.14) =$ **69.23 mA**

Chapter 4, Problem 97.

A common-emitter amplifier circuit is shown in Fig. 4.152. Obtain the Thevenin equivalent to the left of points ***B*** and ***E***.

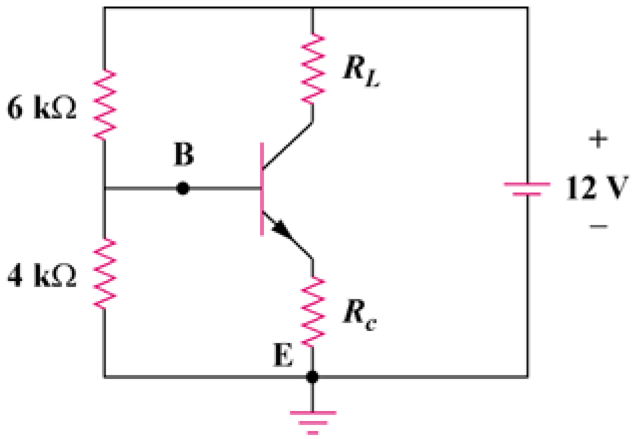
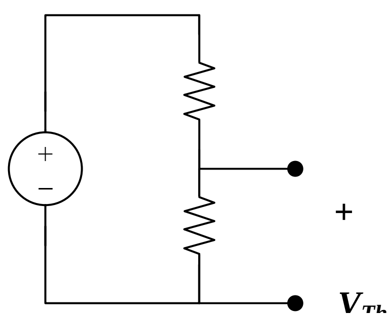


Figure 4.152

Chapter 4, Solution 97.



$$R_{Th} = R_1||R_2 = 6||4 = \underline{\mathbf{2.4\ k\ ohms}}$$

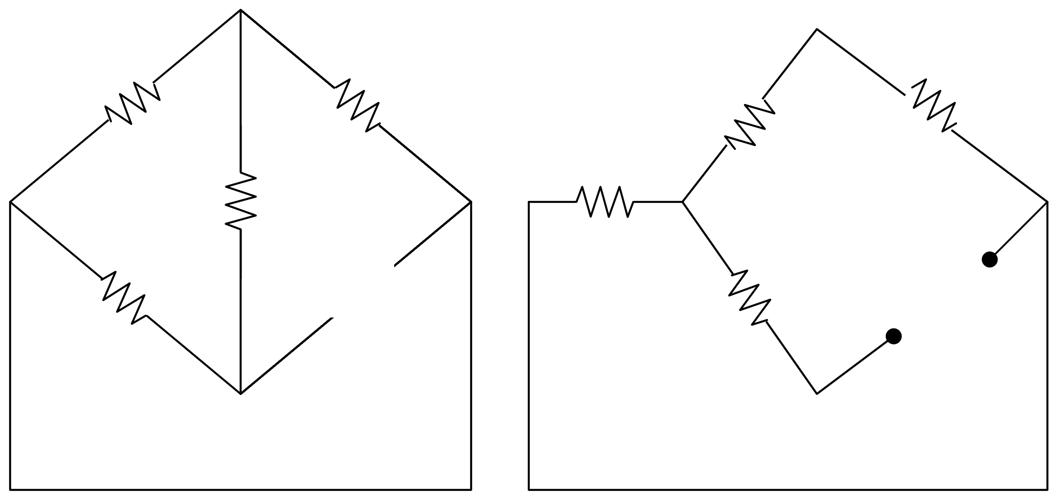
$$V_{Th} = [R_2/(R_1 + R_2)]v_s = [4/(6+4)](12) = \underline{\mathbf{4.8\ V}}$$

Chapter 4, Problem 98.

For Practice Prob. 4.18, determine the current through the 40-Ω resistor and the power dissipated by the resistor.

Chapter 4, Solution 98.

The 20-ohm, 60-ohm, and 14-ohm resistors form a delta connection which needs to be connected to the wye connection as shown in Fig. (b),



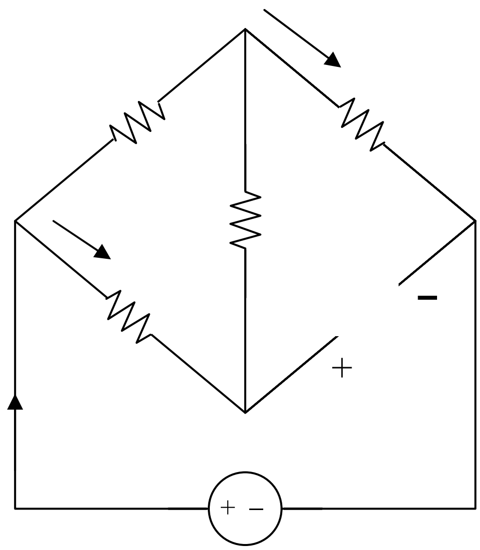
$$R_1 = 20x60/(20 + 60 + 14) = 1200/94 = 12.766 \text{ ohms}$$

$$R_2 = 20x14/94 = 2.979 \text{ ohms}$$

$$R_3 = 60x14/94 = 8.936 \text{ ohms}$$

$$R_{Th} = R_3 + R_1||(R_2 + 30) = 8.936 + 12.766||32.98 = 18.139 \text{ ohms}$$

To find V_{Th}, consider the circuit in Fig. (c).



$$I_T = 16/(30 + 15.745) = 349.8 \text{ mA}$$

$$I_1 = [20/(20 + 60 + 14)]I_T = 74.43 \text{ mA}$$

$$V_{Th} = 14I_1 + 30I_T = 11.536 \text{ V}$$

$$I_{40} = V_{Th}/(R_{Th} + 40) = 11.536/(18.139 + 40) = 198.42 \text{ mA}$$

$$P_{40} = I_{40}^2R = \underline{\mathbf{1.5748 \text{ watts}}}$$