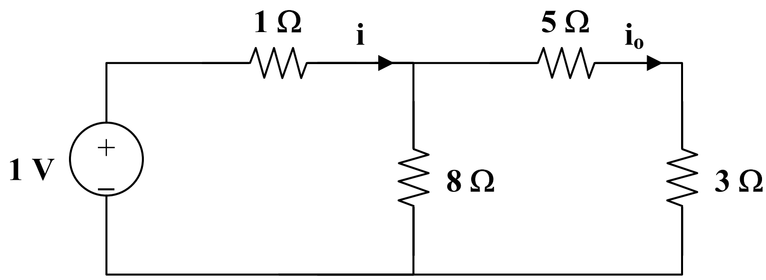
**Chapter 4, Solution 1.**



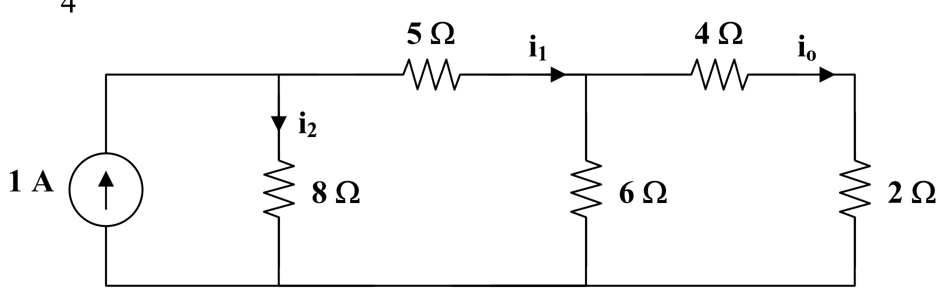

$8\|(5+3) = 4\Omega\,,\quad i = \dfrac{1}{1+4} = \dfrac{1}{5}$

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

**Chapter 4, Solution 2.**

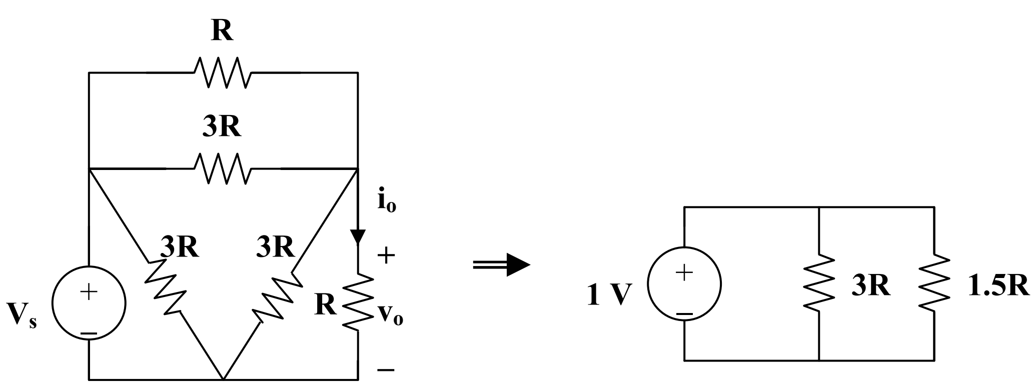
$6\|(4+2) = 3\Omega,\quad i_1 = i_2 = \dfrac{1}{2}A$

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




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

**Chapter 4, Solution 3.**




**(a)**

**(b)**

(a) We transform the Y sub-circuit to the equivalent $\Delta$.

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

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

$i_o = v_o/(R)$

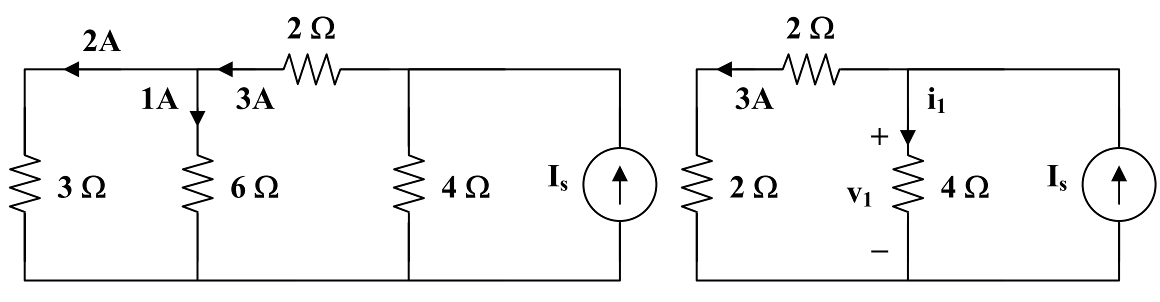
When $v_s = 1V$, $v_o =$ **<u>0.5V</u>**, $i_o =$ **<u>0.5A</u>**

(b) When $v_s = 10V$, $v_o =$ **<u>5V</u>**, $i_o =$ **<u>5A</u>**

(c) When $v_s = 10V$ and $R = 10\Omega$,
$v_o =$ **<u>5V</u>**, $i_o = 10/(10) =$ **<u>500mA</u>**

**Chapter 4, Solution 4.**

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




**(a)** **(b)**

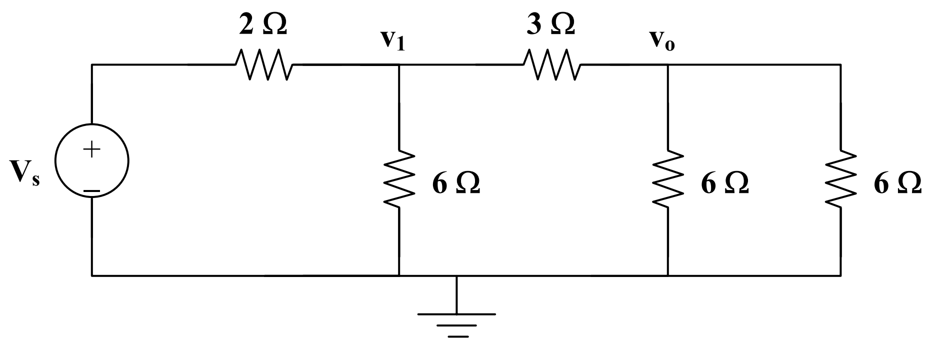
$$3\|6 = 2\Omega, \; v_o = 3(4) = 12V, \; i_1 = \frac{v_o}{4} = 3A.$$

Hence $I_s = 3 + 3 = 6A$

If $I_s = 6A \longrightarrow I_o = 1$

$I_s = 9A \longrightarrow I_o = 6/(9) =$ **<u>0.6667A</u>**

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

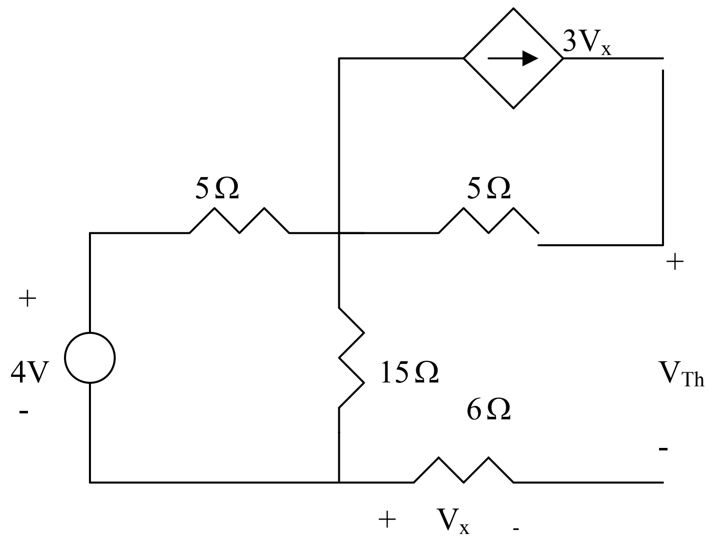
**Chapter 4, Solution 6**

Let $R_T = R_2 // R_3 = \frac{R_2 R_3}{R_2 + R_3}$, then $V_o = \frac{R_T}{R_T + R_1} V_s$

$$k = \frac{V_o}{V_s} = \frac{R_T}{R_T + R_1} = \frac{\frac{R_2 R_3}{R_2 + R_3}}{\frac{R_2 R_3}{R_2 + R_3} + R_1} = \underline{\frac{R_2 R_3}{R_1 R_2 + R_2 R_3 + R_3 R_1}}$$

**Chapter 4, Solution 7**

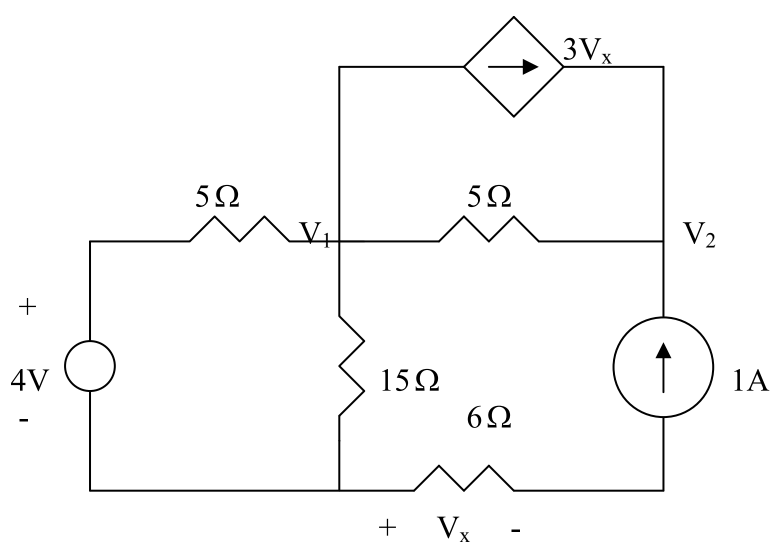
We find the Thevenin equivalent across the 10-ohm resistor. To find $V_{Th}$, consider the circuit below.




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,

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

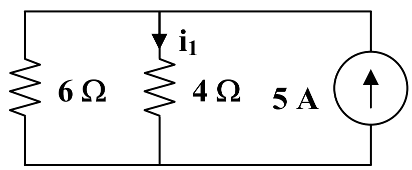
Solving (1) and (2) leads to $V_2$ = 101.75 V

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

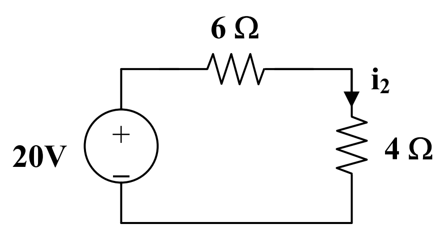
**Chapter 4, Solution 8.**

Let i = $i_1$ + $i_2$,

where $i_1$ and $i_L$ are due to current and voltage sources respectively.




**(a)**




**(b)**

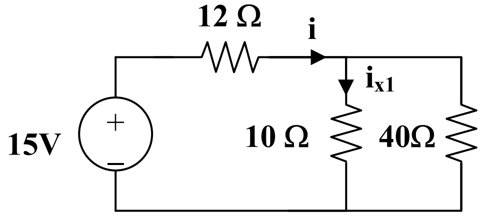
$$i_1=\frac{6}{6+4}(5)=3\text{A}, \quad i_2=\frac{20}{6+4}=2\text{A}$$

Thus i = $i_1$ + $i_2$ = 3 + 2 = **<u>5A</u>**

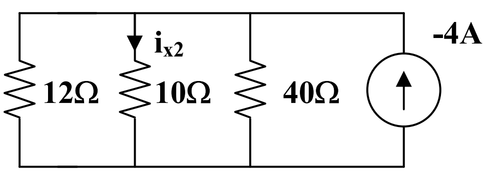
**Chapter 4, Solution 9.**

Let $i_x=i_{x_1}+i_{x_2}$

where $i_{x_1}$ is due to 15V source and $i_{x_2}$ is due to 4A source,




**(a)**




**(b)**

For $i_{x1}$, consider Fig. (a).

$$10||40 = 400/50 = 8 \text{ ohms}, \quad i = 15/(12 + 8) = 0.75$$

$$i_{x1} = [40/(40 + 10)]i = (4/5)0.75 = 0.6$$

For $i_{x2}$, consider Fig. (b).

$$12||40 = 480/52 = 120/13$$

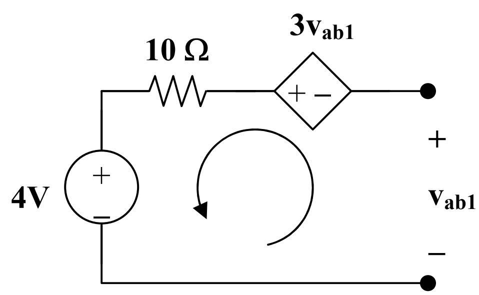
$$i_{x2} = [(120/13)/((120/13) + 10)](-4) = -1.92$$

$$i_x = 0.6 – 1.92 = \underline{\mathbf{-1.32\ A}}$$

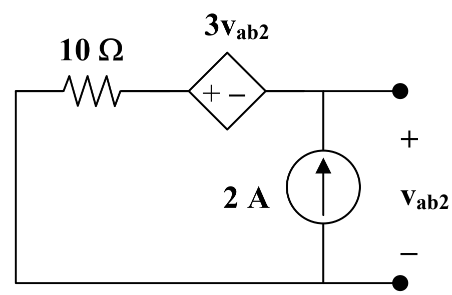
$p = vi_x = i_x^2R = (-1.32)^2 10 = $ **<u>17.43 watts</u>**

**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.




(a)




(b)

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

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

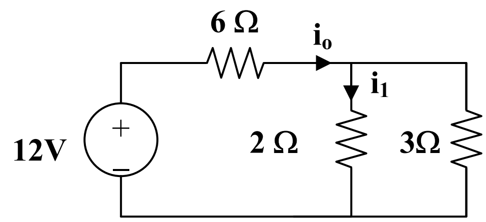
For $v_{ab2}$, consider Fig. (b). Applying KVL gives,

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

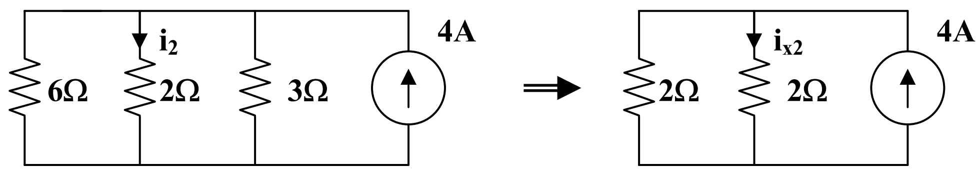
$v_{ab} = 1 + 5 = $ **<u>6 V</u>**

**Chapter 4, Solution 11.**

Let $i = i_1 + i_2$, where $i_1$ is due to the 12-V source and $i_2$ is due to the 4-A source.




**(a)**




**(b)**

For $i_1$, consider Fig. (a).

$$2||3 = 2x3/5 = 6/5, \quad i_o = 12/(6 + 6/5) = 10/6$$

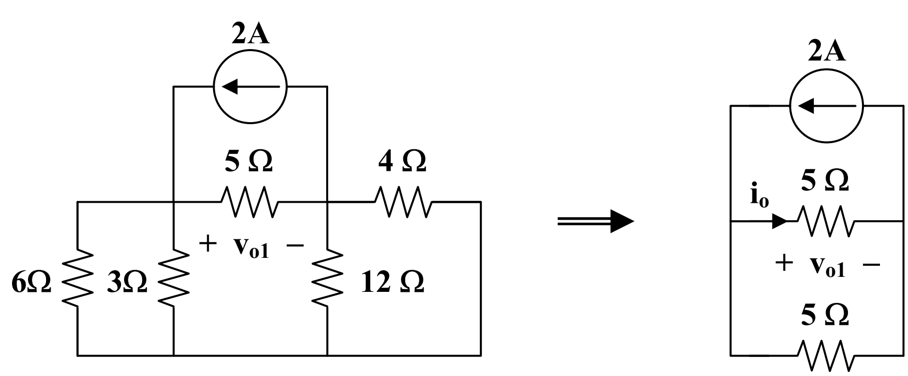
$$i_1 = [3/(2 + 3)]i_o = (3/5)x(10/6) = 1 \text{ A}$$

For $i_2$, consider Fig. (b), $6||3 = 2$ ohm, $i_2 = 4/2 = 2$ A

$$i = 1 + 2 = \underline{\mathbf{3\ A}}$$

**Chapter 4, Solution 12.**

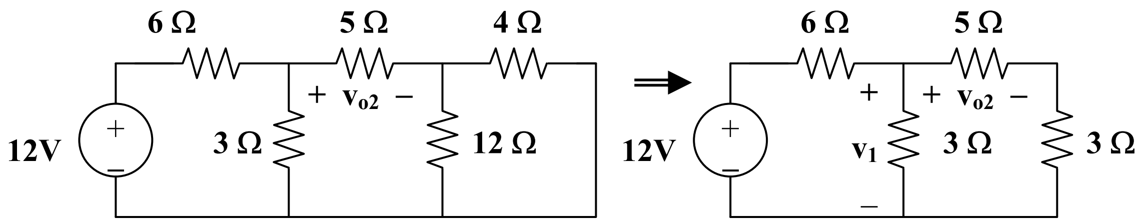
Let $v_o = v_{o1} + v_{o2} + v_{o3}$, where $v_{o1}$, $v_{o2}$, and $v_{o3}$ are due to the 2-A, 12-V, and 19-V sources respectively. For $v_{o1}$, consider the circuit below.



$6||3 = 2$ ohms, $4||12 = 3$ ohms. Hence,

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

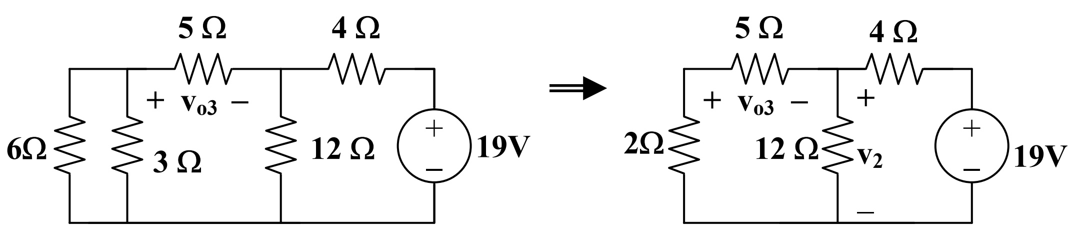
For $v_{o2}$, consider the circuit below.




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

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

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




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

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

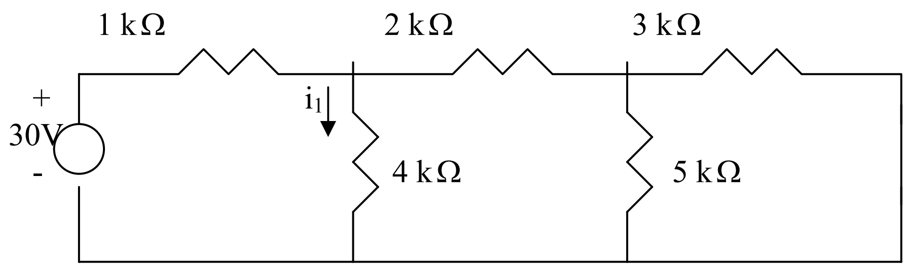
$v_o = 5 + 2 – 7.125 =$ **<u>-125 mV</u>**

**Chapter 4, Solution 13**

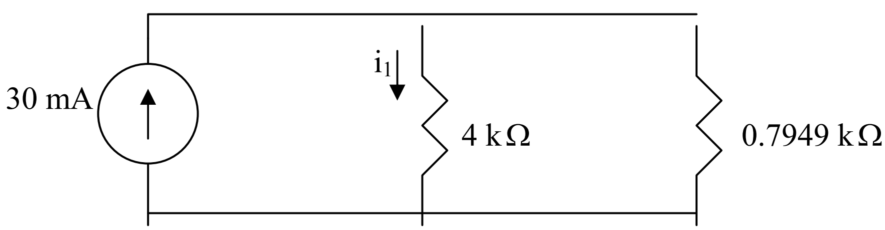
Let

$$i_o = i_1 + i_2 + i_3,$$

where $i_1$, $i_2$, and $i_3$ are the contributions to $i_o$ due to 30-V, 15-V, and 6-mA sources respectively. For $i_1$, consider the circuit below.



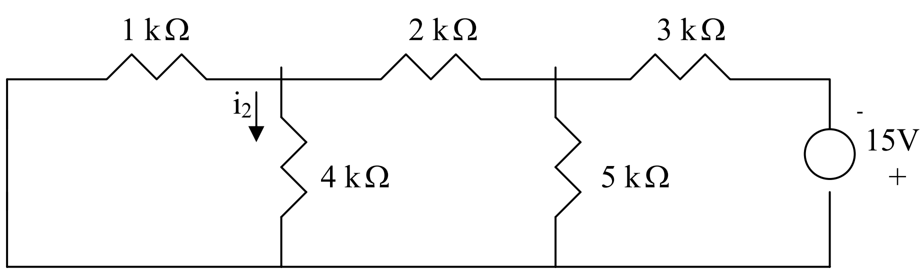

3//5 = 15/8 = 1.875 kohm, 2 + 3//5 = 3.875 kohm, 1//3.875 = 3.875/4.875 = 0.7949 kohm. After combining the resistors except the 4-kohm resistor and transforming the voltage source, we obtain the circuit below.



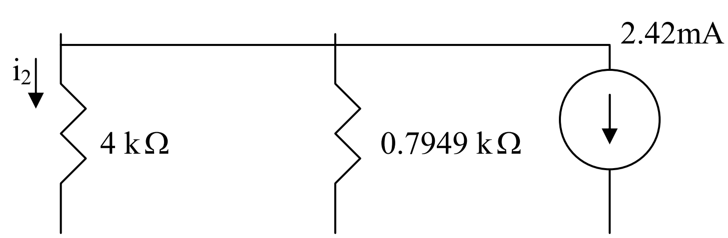

Using current division,

$$i_1 = \frac{0.7949}{4.7949}(30\text{mA}) = 4.973\text{ mA}$$

For $i_2$, consider the circuit below.



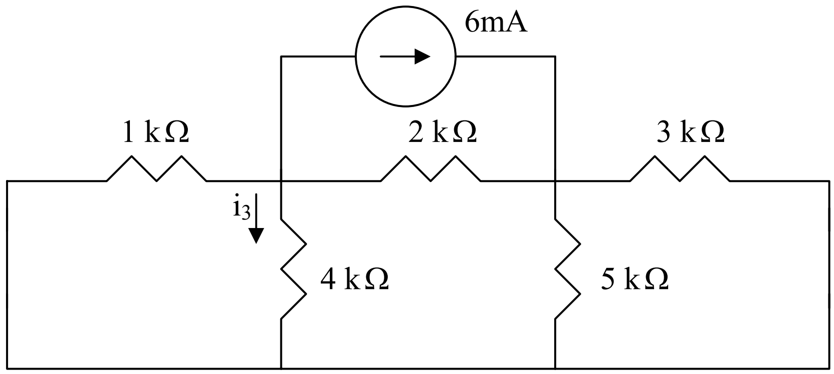

After successive source transformation and resistance combinations, we obtain the circuit below:



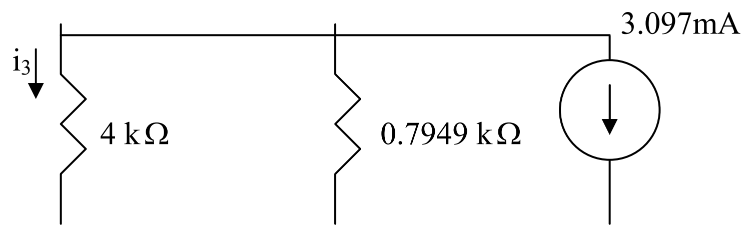

Using current division,

$$i_2 = -\frac{0.7949}{4.7949}(2.42\text{mA}) = -0.4012\text{ mA}$$

For $i_3$, consider the circuit below.




After successive source transformation and resistance combinations, we obtain the circuit below:



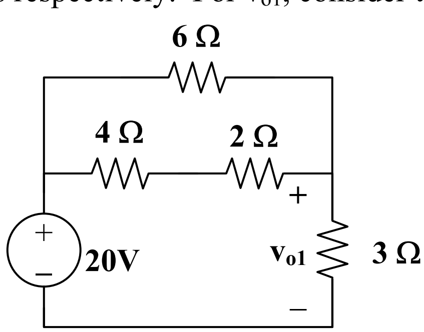

$$i_3 = -\frac{0.7949}{4.7949}(3.097\text{mA}) = -0.5134\text{ mA}$$

Thus,

$$i_o = i_1 + i_2 + i_3 = \underline{4.058\text{ mA}}$$

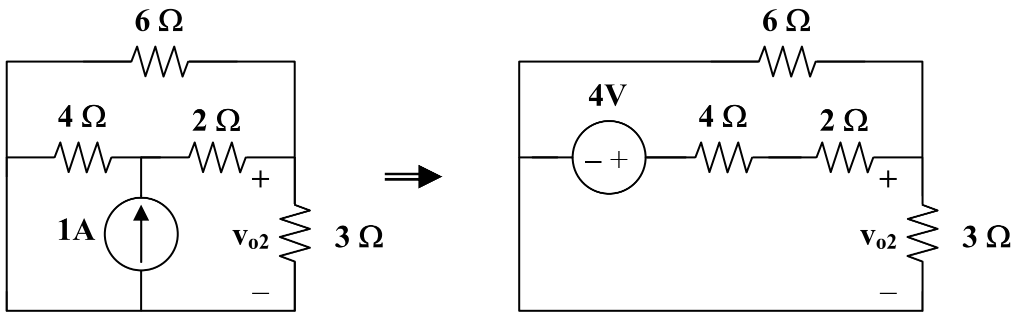
**Chapter 4, Solution 14.**

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.



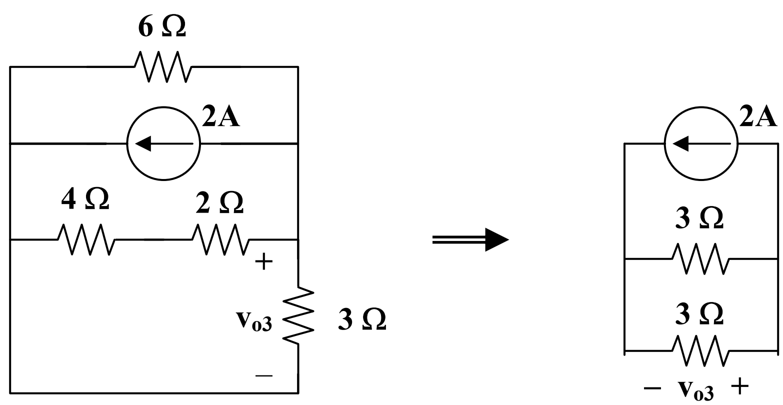

$$6\|(4 + 2) = 3 \text{ ohms},\ v_{o1} = (½)20 = 10 \text{ V}$$

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.

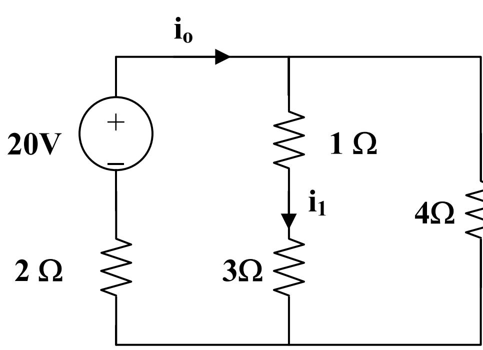



$$6\|(4+2) = 3, \; v_{o3} = (-1)3 = -3$$

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

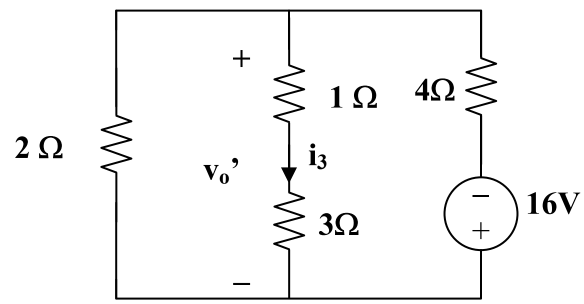
**Chapter 4, Solution 15.**

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.



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

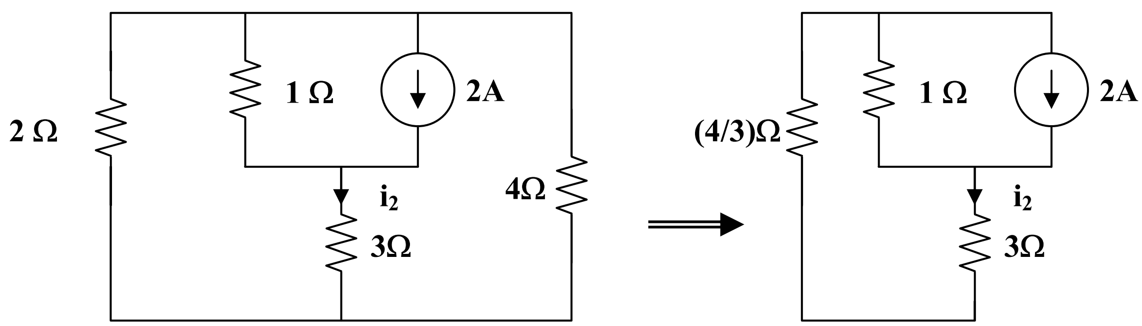
For $i_3$, consider the circuit below.




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

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

For $i_2$, consider the circuit below.




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

Using the current division principle.

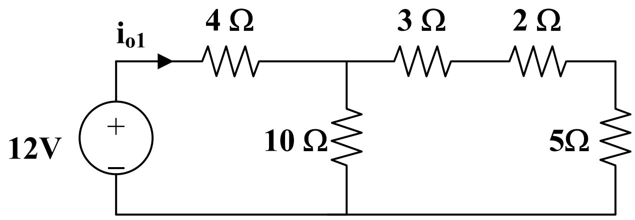
$$i_2 = [1/(1 + 13/2)]2 = 3/8 = 0.375$$

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

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

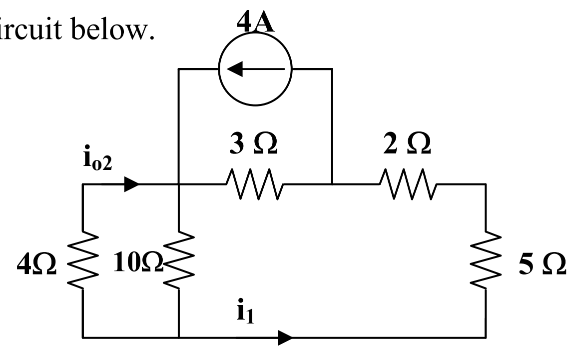
**Chapter 4, Solution 16.**

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.



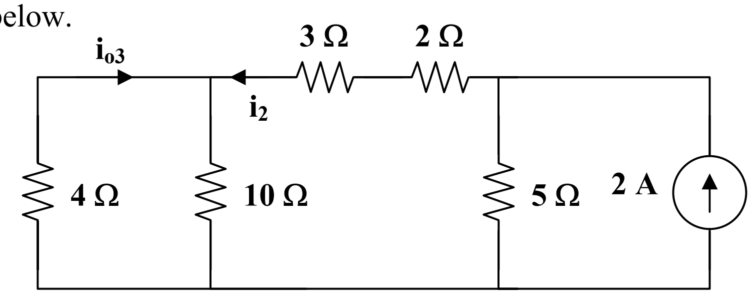

$$10||(3 + 2 + 5) = 5 \text{ ohms}, \quad i_{o1} = 12/(5 + 4) = (12/9) \text{ A}$$

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.



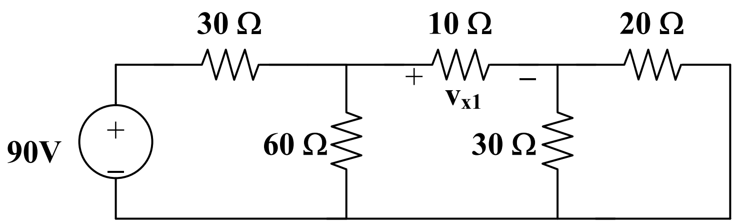

$$3 + 2 + 4||10 = 5 + 20/7 = 55/7$$

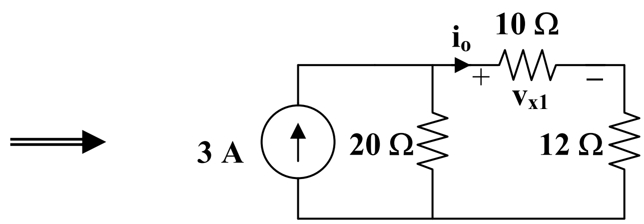
$$i_2 = [5/(5 + 55/7)]2 = 7/9, \quad i_{o3} = [-10/(10 + 4)]i_2 = -5/9$$

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

**Chapter 4, 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.



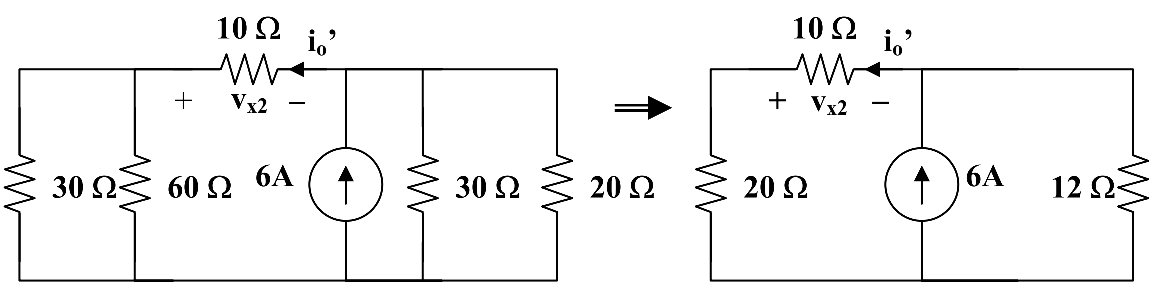




$$20||30 = 12 \text{ ohms}, \quad 60||30 = 20 \text{ ohms}$$

By using current division,

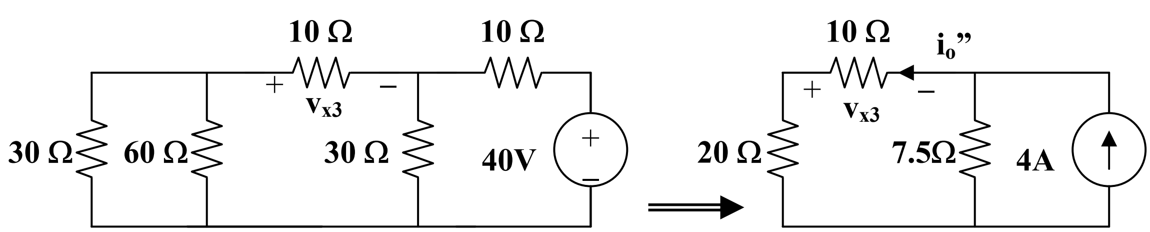
$$i_o = [20/(22 + 20)]3 = 60/42, \quad v_{x1} = 10i_o = 600/42 = 14.286 \text{ V}$$

For $v_{x2}$, consider the circuit below.




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

For $v_{x3}$, consider the circuit below.

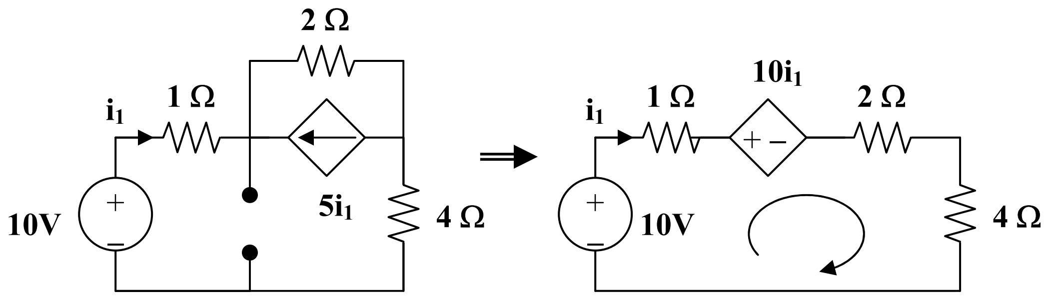



$$i_o'' = [12/(12 + 30)]2 = 24/42, \quad v_{x3} = -10i_o'' = -5.714$$

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

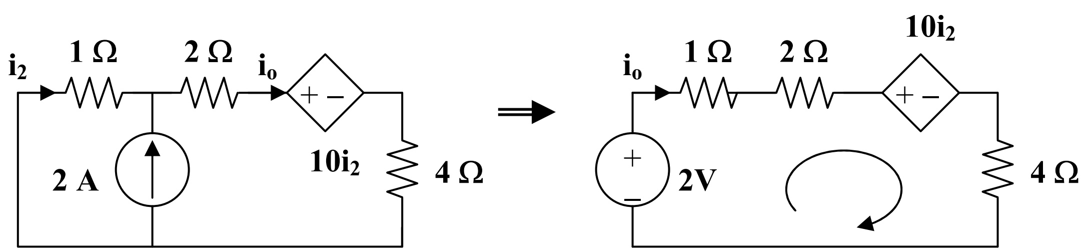
**Chapter 4, Solution 18.**

Let $i_x = i_1 + i_2$, where $i_1$ and $i_2$ are due to the 10-V and 2-A sources respectively. To obtain $i_1$, consider the circuit below.




$$-10 + 10i_1 + 7i_1 = 0, \text{ therefore } i_1 = (10/17) \text{ A}$$

For $i_2$, consider the circuit below.



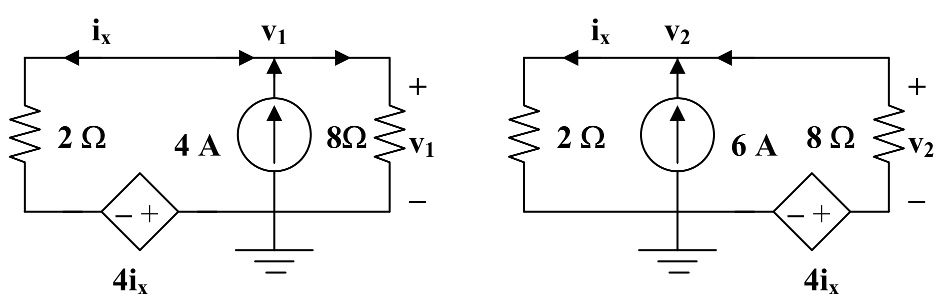

$$-2 + 10i_2 + 7i_o = 0, \text{ but } i_2 + 2 = i_o. \text{ Hence,}$$

$$-2 + 10i_2 + 7i_2 + 14 = 0, \text{ or } i_2 = (-12/17) \text{ A}$$

$v_x = 1xi_x = 1(i_1 + i_2) = (10/17) – (12/17) = -2/17 =$ **-117.6 mA**

**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.




**(a)** **(b)**

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

$$v_1/8 = 4 + (-4i_x - v_1)/2$$

But, $-i_x = (-4i_x - v_1)/2$ and we have $-2i_x = v_1$. Thus,

$$v_1/8 = 4 + (2v_1 - v_1)/8, \text{ which leads to } v_1 = -32/3$$

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

$$v_2/2 = 6 + (4i_x - v_2)/8$$

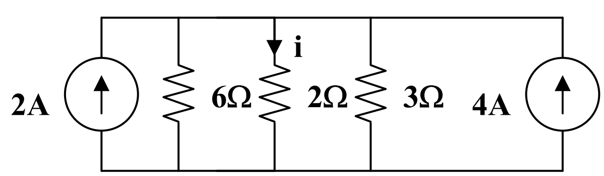
But $i_x = v_2/2$ and $2i_x = v_2$. Therefore,

$$v_2/2 = 6 + (2v_2 - v_2)/8 \text{ which leads to } v_2 = -16$$

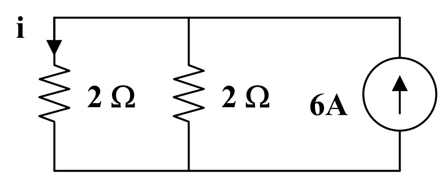
Hence, $vx = -(32/3) - 16 = \underline{\mathbf{-26.67\ V}}$

**Chapter 4, Solution 20.**

Transform the voltage sources and obtain the circuit in Fig. (a). Combining the 6-ohm and 3-ohm resistors produces a 2-ohm resistor (6||3 = 2). Combining the 2-A and 4-A sources gives a 6-A source. This leads to the circuit shown in Fig. (b).




**(a)**

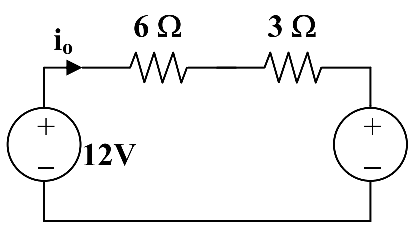



**(b)**

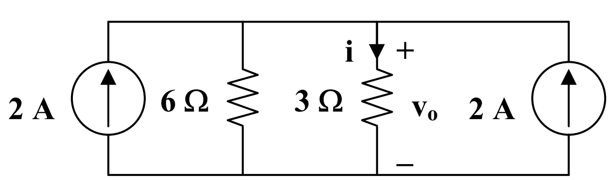
From Fig. (b), $i = 6/2 = \underline{\mathbf{3\ A}}$

**Chapter 4, Solution 21.**

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




**(a)**




**(b)**

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

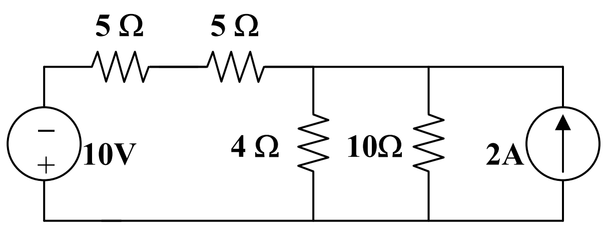
To get $v_o$, transform the voltage sources as shown in Fig. (b).

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

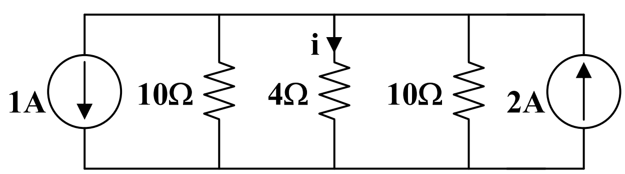
$v_o = 3i$ = **8 V**

**Chapter 4, Solution 22.**

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




**(a)**



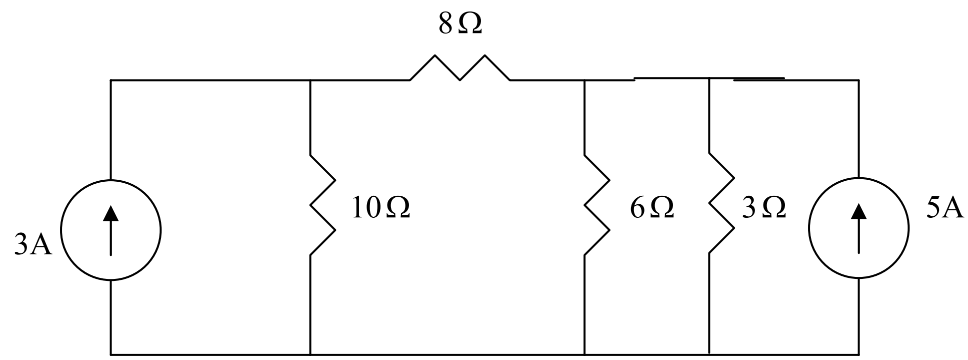

**(b)**

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

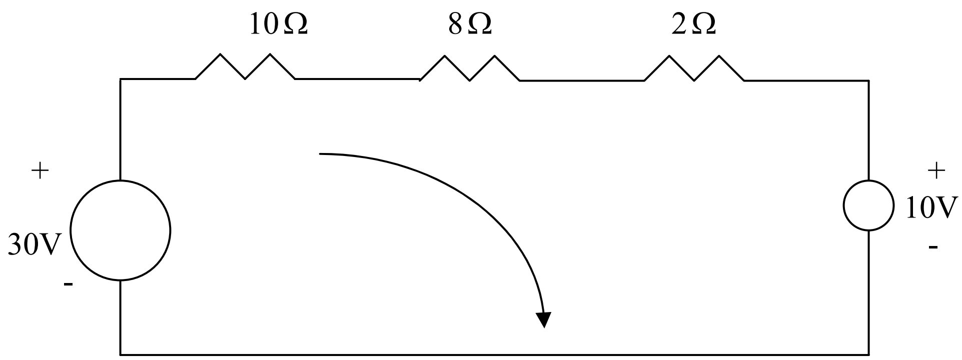
$10||10 = 5$ ohms, $i = [5/(5 + 4)](2 - 1) = 5/9$ = **555.5 mA**

**Chapter 4, 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.



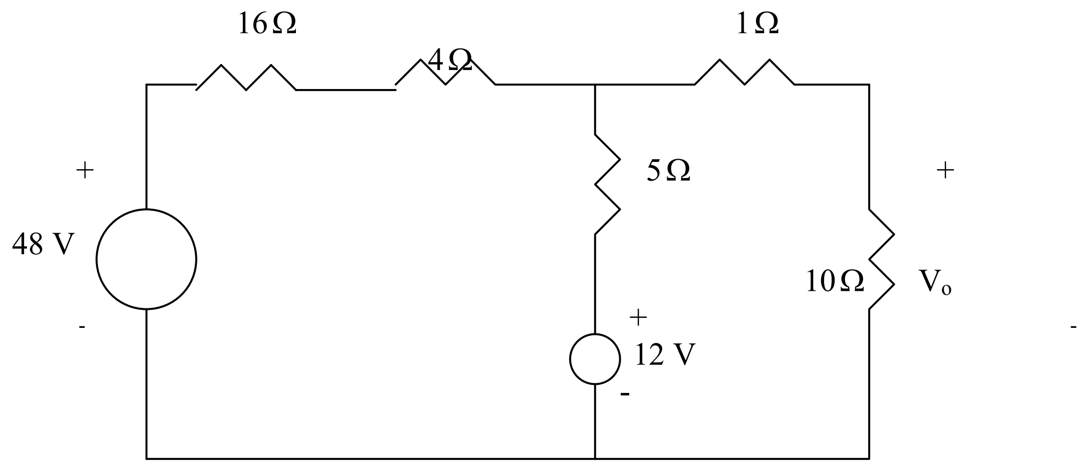

Applying KVL to the loop gives

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

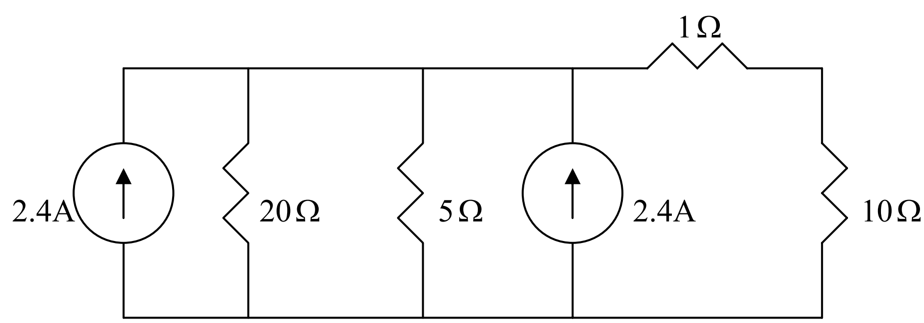
$$p = VI = I^2 R = \underline{8\ \text{W}}$$

**Chapter 4, Solution 24**

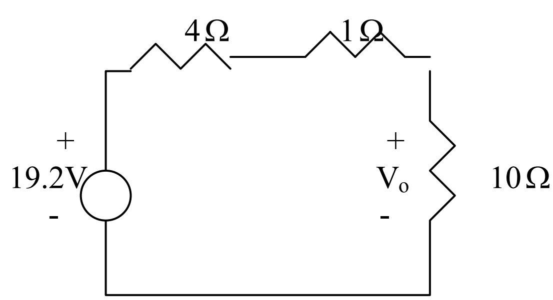
Convert the current source to voltage source.




Combine the 16-ohm and 4-ohm resistors and convert both voltages sources to current Sources. We obtain the circuit below.




Combine the resistors and current sources.
20//5 = (20x5)/25 = 4Ω, 2.4 + 2.4 = 4.8 A
Convert the current source to voltage source. We obtain the circuit below.

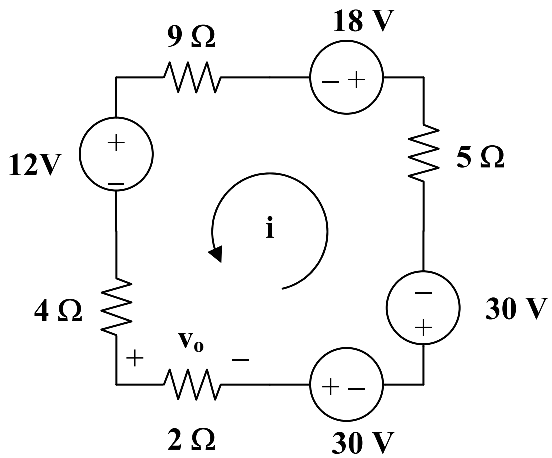



Using voltage division,

$$V_o = \frac{10}{10+4+1}(19.2) = \underline{12.8} \text{ V}$$

**Chapter 4, Solution 25.**

Transforming only the current source gives the circuit below.




Applying KVL to the loop gives,

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

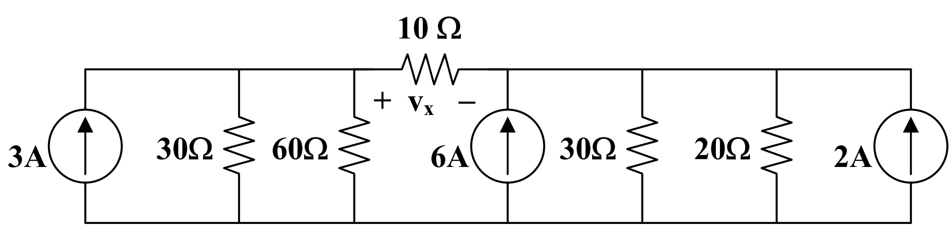
$$20i = 90 \text{ which leads to } i = 4.5$$

$v_o = 2i =$ **9 V**

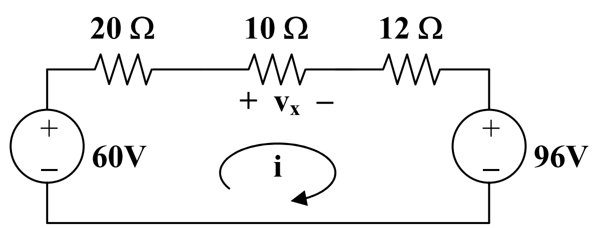
**Chapter 4, Solution 26.**

Transform the voltage sources to current sources. The result is shown in Fig. (a),

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




**(a)**




**(b)**

Combining the resistors and transforming the current sources to voltage sources, we obtain the circuit in Fig. (b). Applying KVL to Fig. (b),

$$42i - 60 + 96 = 0, \text{ which leads to } i = -36/42$$

$v_x = 10i =$ **-8.571 V**

**Chapter 4, Solution 27.**

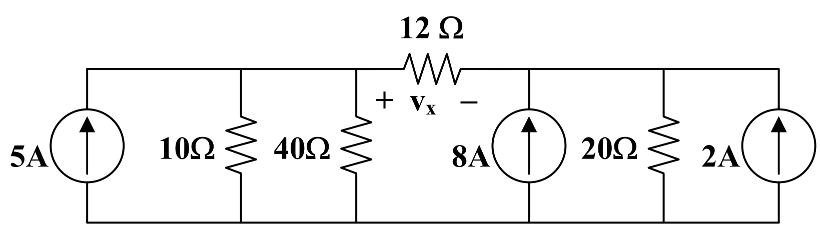
Transforming the voltage sources to current sources gives the circuit in Fig. (a).

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

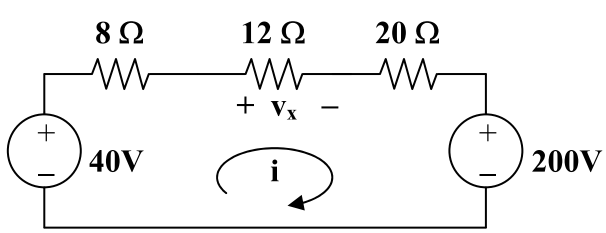
Transforming the current sources to voltage sources yields the circuit in Fig. (b). Applying KVL to the loop,

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

$v_x$ $12i =$ **-48 V**



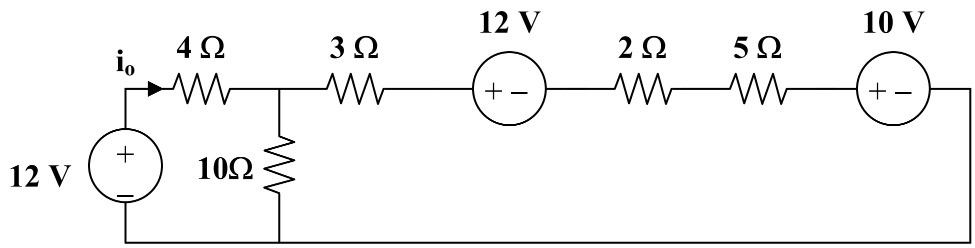

**(a)**



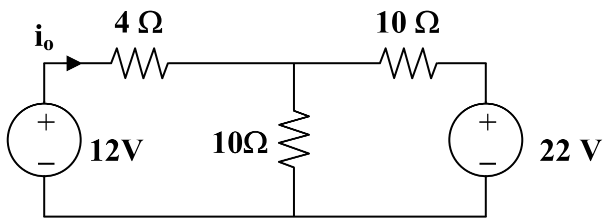

**(b)**

**Chapter 4, Solution 28.**

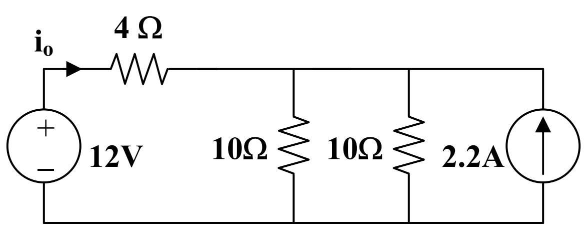
Transforming only the current sources leads to Fig. (a). Continuing with source transformations finally produces the circuit in Fig. (d).



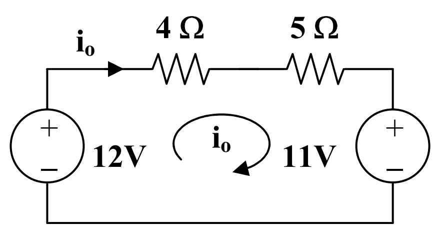

(a)




(b)




(c)



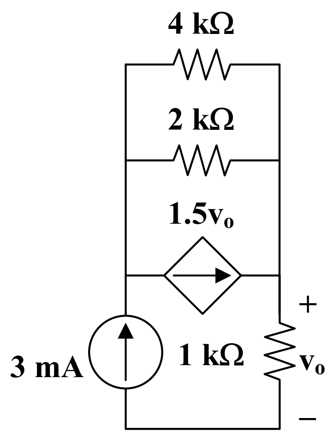

(d)

Applying KVL to the loop in fig. (d),

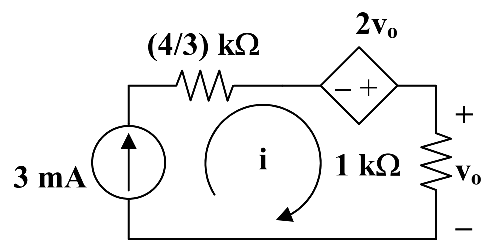
$$-12 + 9i_o + 11 = 0, \text{ produces } i_o = 1/9 = \underline{\textbf{111.11 mA}}$$

**Chapter 4, Solution 29.**

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




(a)



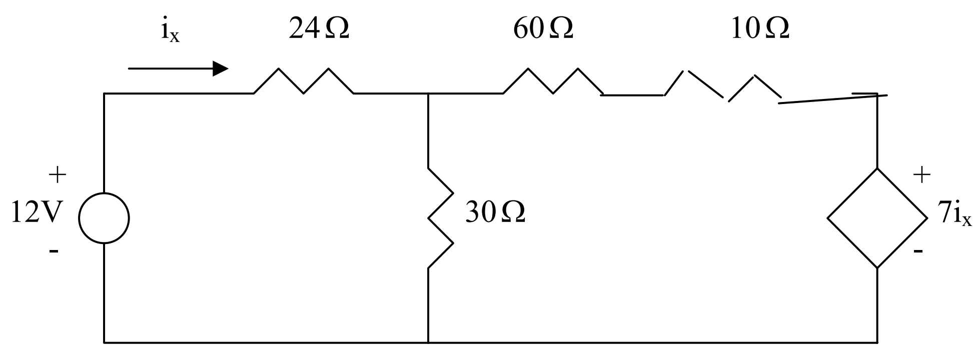

(b)

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

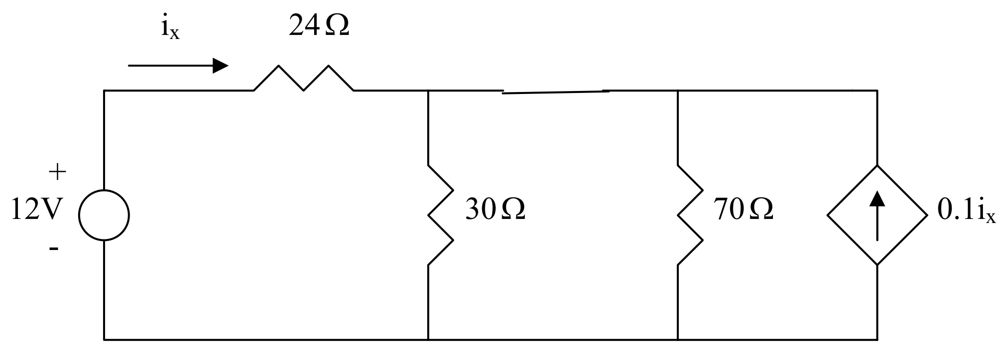
If the use of source transformations was not required for this problem, the actual answer could have been determined by inspection right away since the only current that could have flowed through the 1 k ohm resistor is 3 mA.

**Chapter 4, Solution 30**

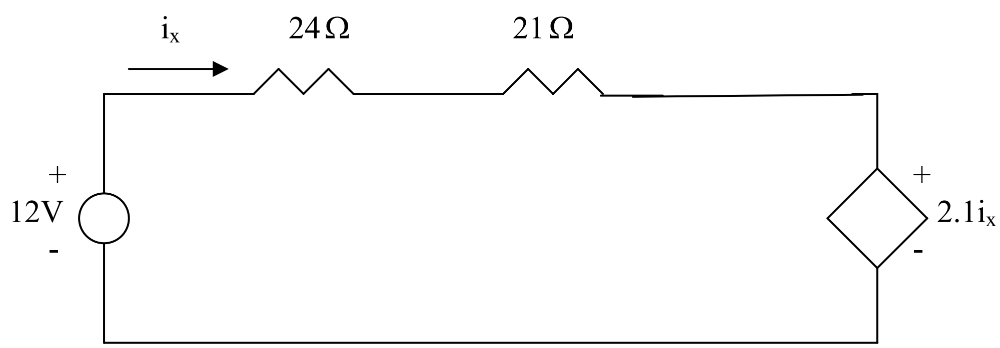
Transform the dependent current source as shown below.




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.

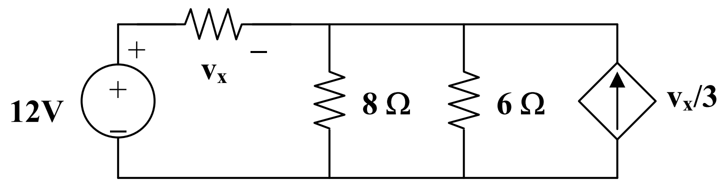



Applying KVL to the loop gives

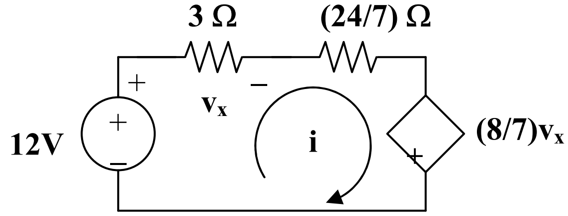
$$45i_x - 12 + 2.1i_x = 0 \quad \longrightarrow \quad i_x = \frac{12}{47.1} = \underline{254.8\text{ mA}}$$

**Chapter 4, 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).




**(a)**




**(b)**

From Fig. (b),

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

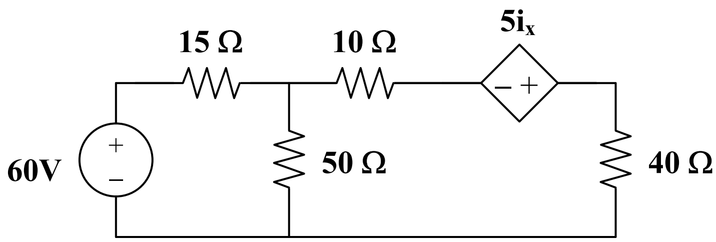
Applying KVL,

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

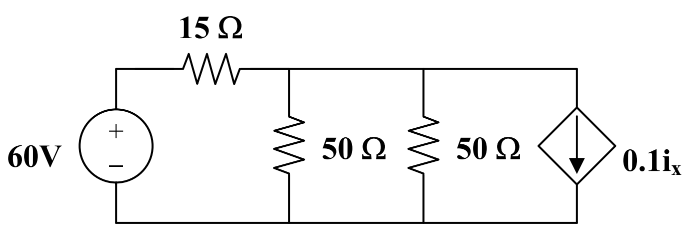
$12 = [(21 + 24)/7]v_x/3 + (8/7)v_x$, leads to $v_x = 84/23 = \underline{\textbf{3.625 V}}$

**Chapter 4, Solution 32.**

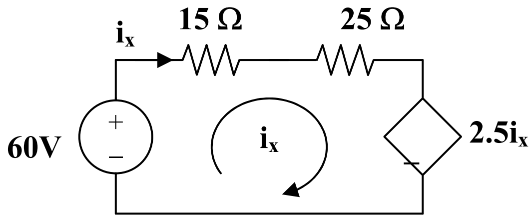
As shown in Fig. (a), we transform the dependent current source to a voltage source,




**(a)**




**(b)**




**(c)**

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

$-60 + 40i_x - 2.5i_x = 0$, or $i_x$ = **1.6 A**

**Chapter 4, Solution 33.**

(a) $R_{Th} = 10||40 = 400/50 =$ **8 ohms**

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

(b) $R_{Th} = 30||60 = 1800/90 =$ **20 ohms**

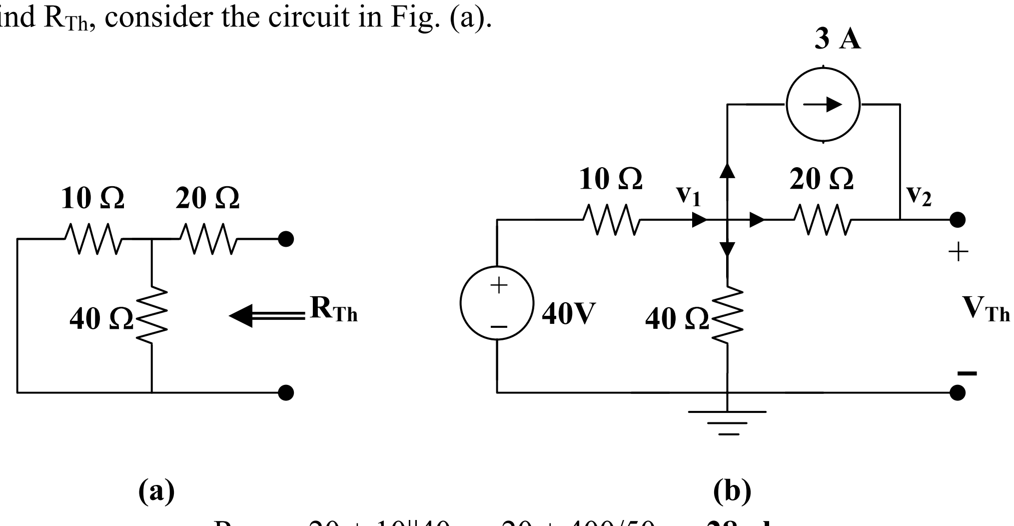
$$2 + (30 - v1)/60 = v_1/30, \text{ and } v_1 = V_{Th}$$

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

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

**Chapter 4, Solution 34.**

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




(a) (b)

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

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)

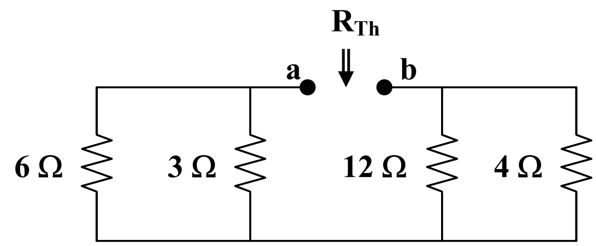
Solving (1) and (2), $v_1 = 32$ V, $v_2 = 92$ V, and $V_{Th} = v_2 =$ **92 V**

**Chapter 4, Solution 35.**

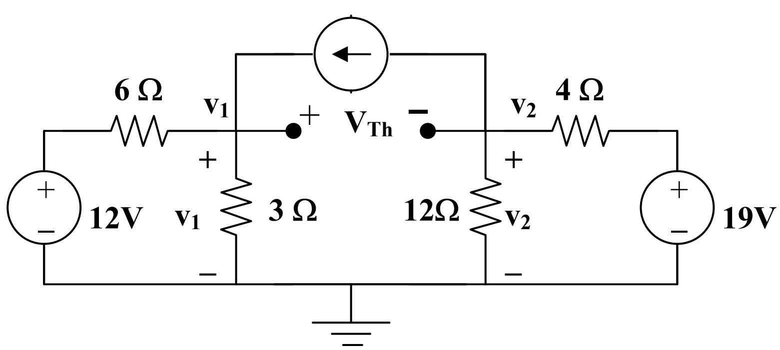
To find $R_{Th}$, consider the circuit in Fig. (a).

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

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




**(a)**

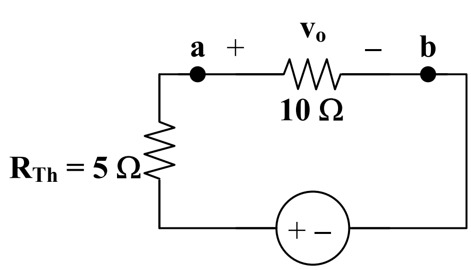



**(b)**

At node 1, $2 + (12 - v_1)/6 = v_1/3$, or $v_1 = 8$

At node 2, $(19 - v_2)/4 = 2 + v_2/12$, or $v_2 = 33/4$

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

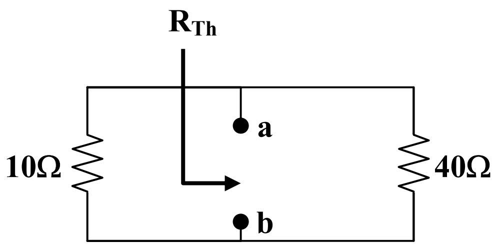



**$V_{Th}$ = (-1/4)V**

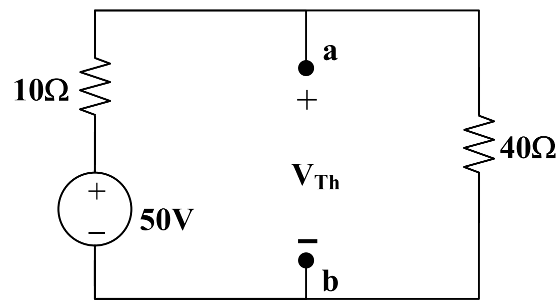
$v_o = V_{Th}/2 = -0.25/2 =$ **-125 mV**

**Chapter 4, Solution 36.**

Remove the 30-V voltage source and the 20-ohm resistor.



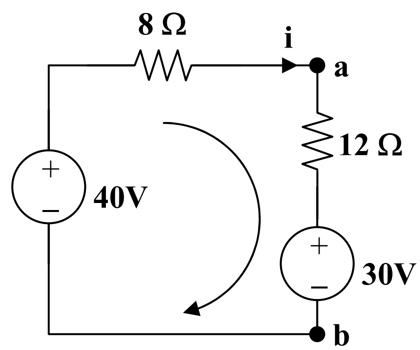

(a)




(b)

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

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



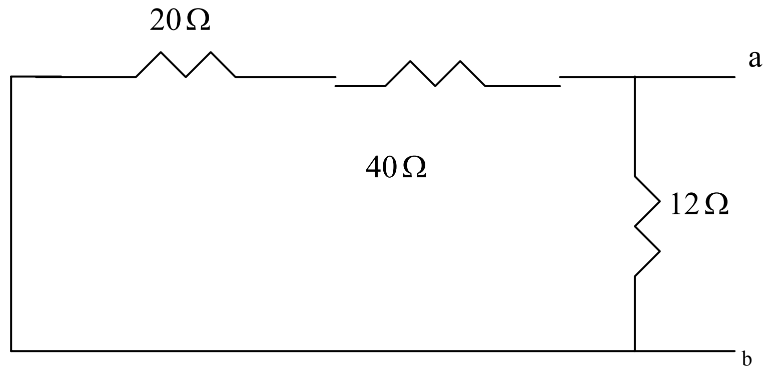

(c)

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

$30 – 40 + (8 + 12)i = 0$, which leads to $i$ = **500mA**

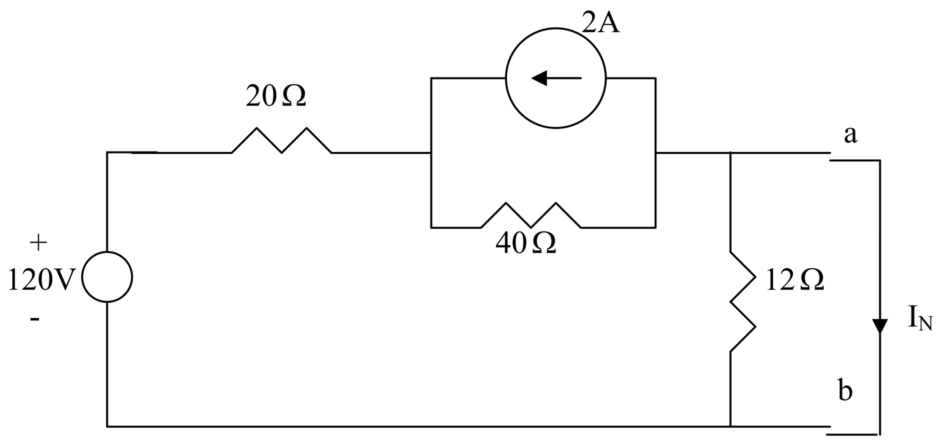
**Chapter 4, Solution 37**

$R_N$ is found from the circuit below.

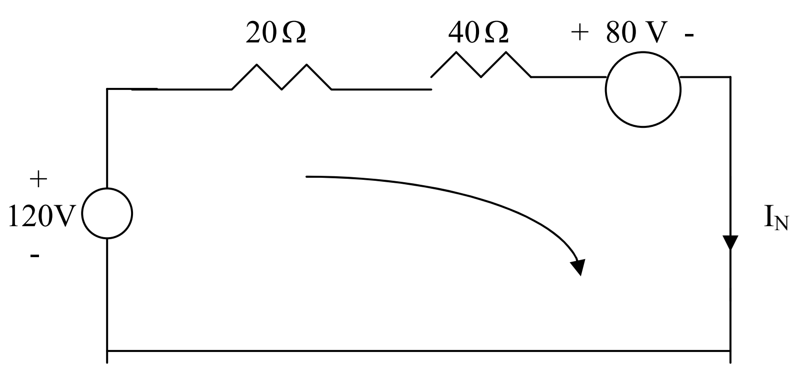



$R_N = 12//(20+40) = \underline{10\Omega}$

$I_N$ is found from the circuit below.




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

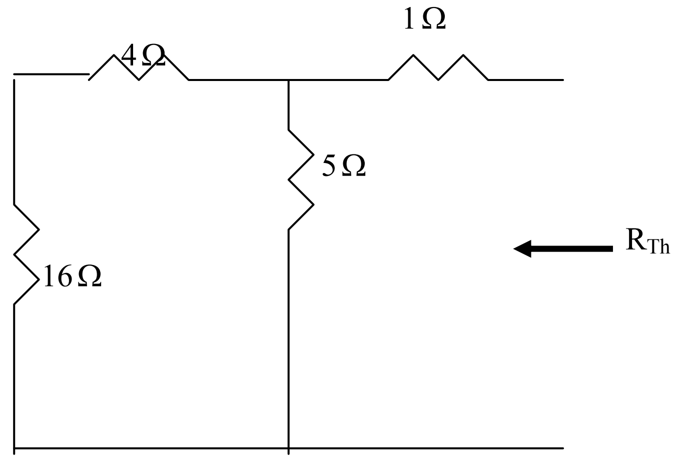



Applying KVL to the loop yields

$-120 + 80 + 60I_N = 0 \quad \longrightarrow \quad I_N = 40/60 = \underline{0.6667\text{ A}}$

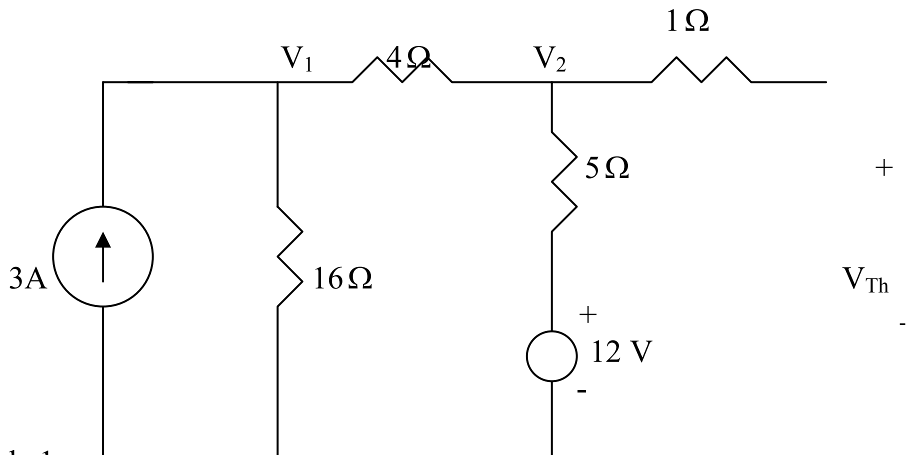
**Chapter 4, Solution 38**

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,

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

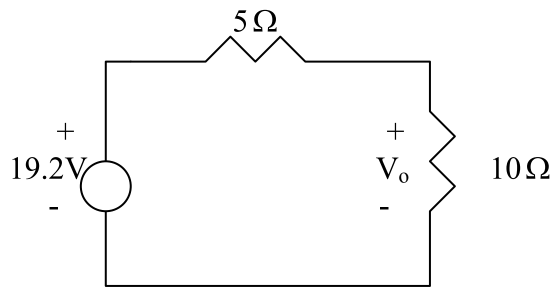
At node 2,

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

Solving (1) and (2) leads to

$$V_{Th} = V_2 = 19.2$$

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

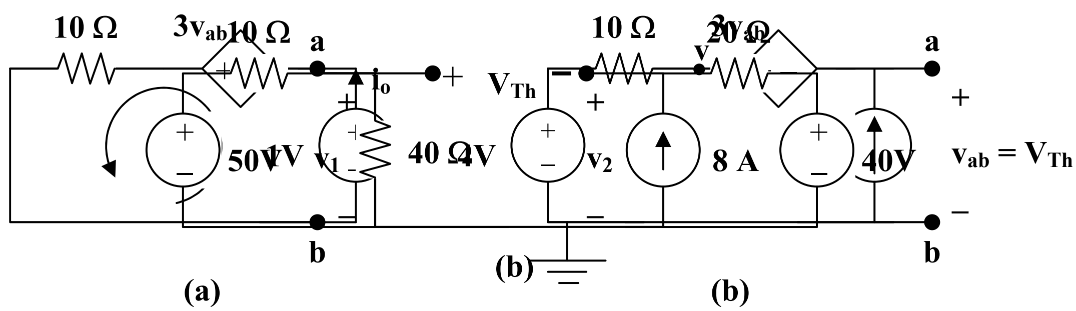



Using voltage division,

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

**Chapter 4, Solution 39.**

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




$$-1 - 3 + 10i_o = 0, \text{ or } i_o = 0.4$$

$$R_{Th} = 1/i_o = 2.5 \text{ ohms}$$

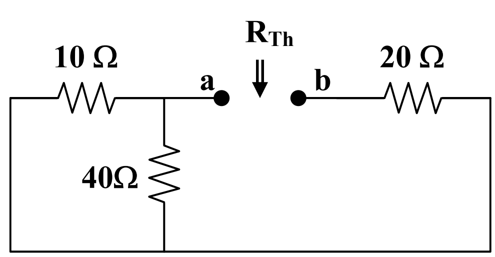
To find $V_{Th}$, consider the circuit shown in Fig. (b).

$$[(4 - v)/10] + 2 = 0, \text{ or } v = 24$$

But, $v = V_{Th} + 3v_{ab} = 4V_{Th} = 24$, which leads to $V_{Th} =$ **<u>6 V</u>**

**Chapter 4, Solution 40.**

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




**(a)**

$$R_{Th} = 10||40 + 20 = 28 \text{ ohms}$$

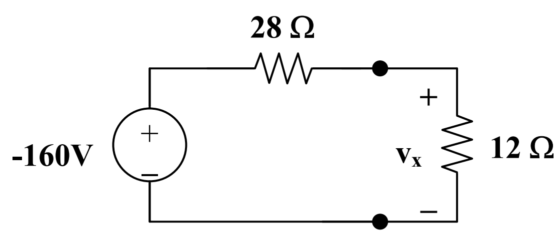
To get $V_{Th}$, consider the circuit in Fig. (b). The two loops are independent. From loop 1,

$$v_1 = (40/50)50 = 40 \text{ V}$$

For loop 2, $-v_2 + 20x8 + 40 = 0$, or $v_2 = 200$

But, $V_{Th} + v_2 - v_1 = 0$, $V_{Th} = v_1 = v_2 = 40 - 200 = -160$ volts

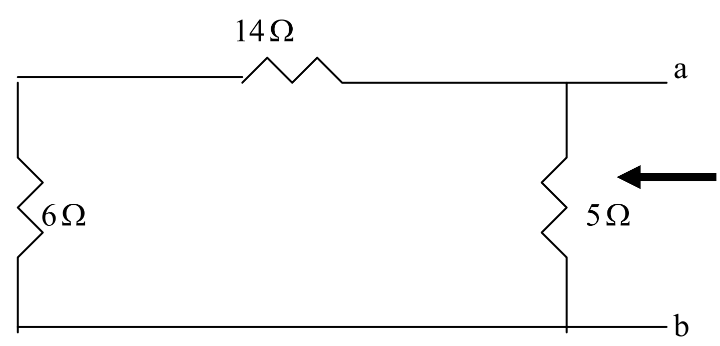
This results in the following equivalent circuit.




$$v_x = [12/(12 + 28)](-160) = \underline{\mathbf{-48\ V}}$$

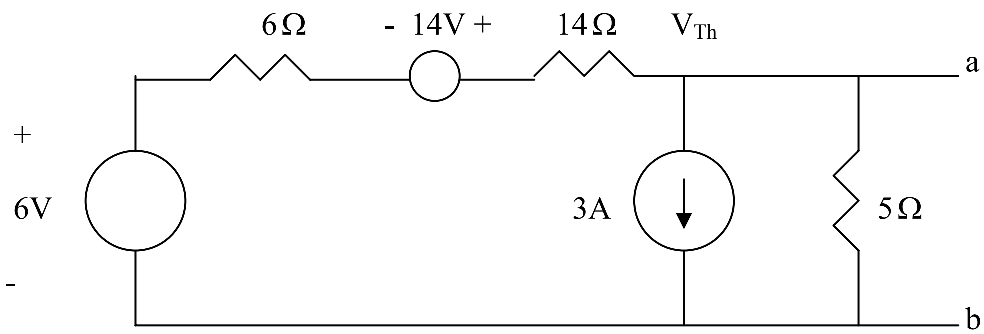
**Chapter 4, Solution 41**

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,

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

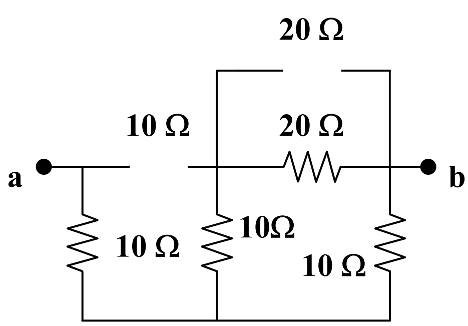
$$I_N = \frac{V_{Th}}{R_{Th}} = (-8)/4 = -2\text{ A}$$

Thus,

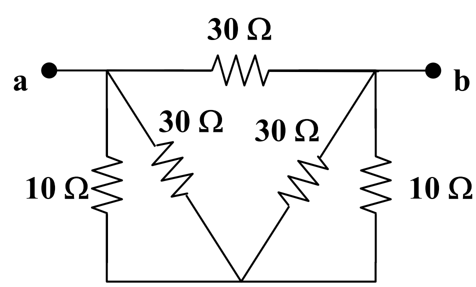
$\underline{R_{Th} = R_N = 4\Omega, \quad V_{Th} = -8\text{V}, \quad I_N = -2\text{ A}}$

**Chapter 4, Solution 42.**

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



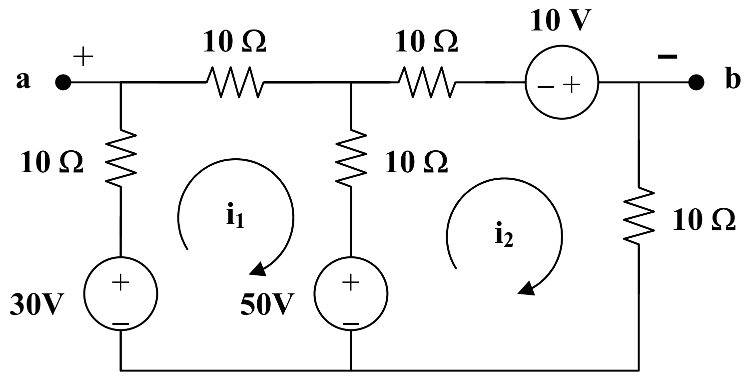

**(a)**




**(b)**

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).




**(c)**

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

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

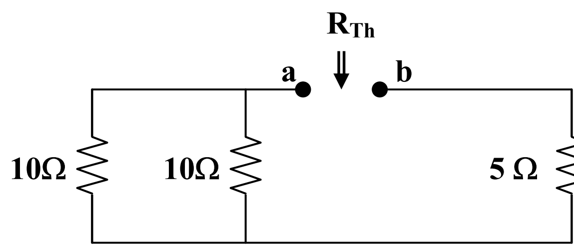
Solving (1) and (2), $i_1 = 0$, $i_2 = 2$ A

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

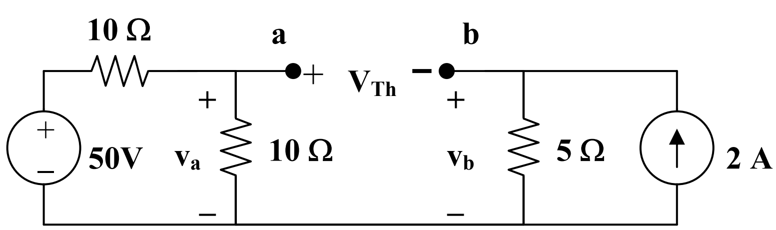
$$V_{Th} = v_{ab} = \underline{\textbf{10 volts}}$$

**Chapter 4, Solution 43.**

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




**(a)**




**(b)**

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

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

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

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

**Chapter 4, Solution 44.**

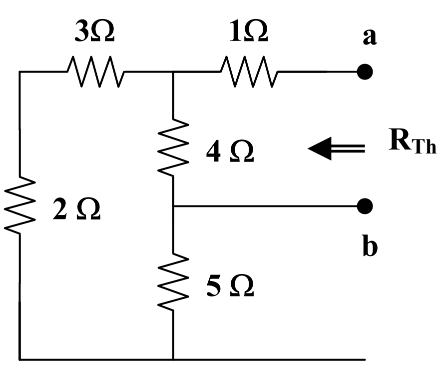
(a) For $R_{Th}$, consider the circuit in Fig. (a).

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

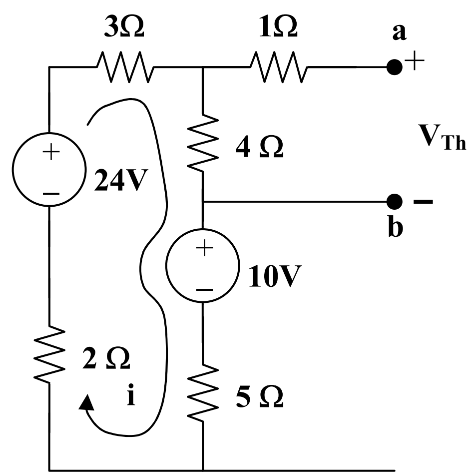
For $V_{Th}$, consider the circuit in Fig. (b). Applying KVL gives,

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

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

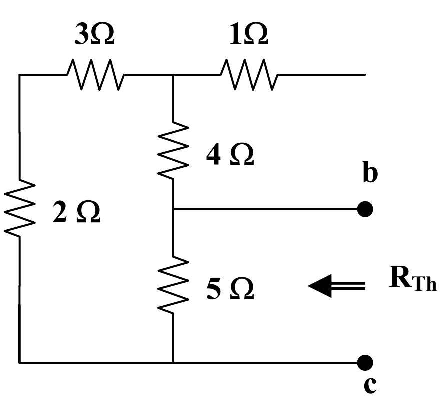



**(a)**

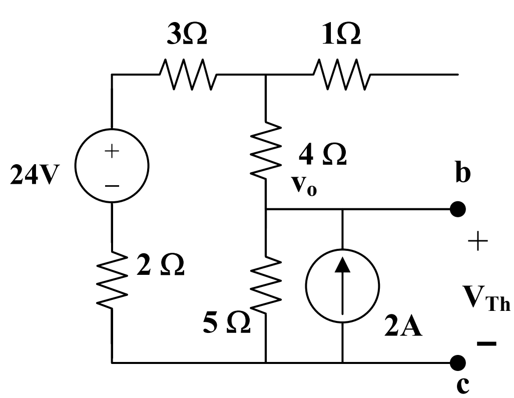



**(b)**

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




**(c)**




**(d)**

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

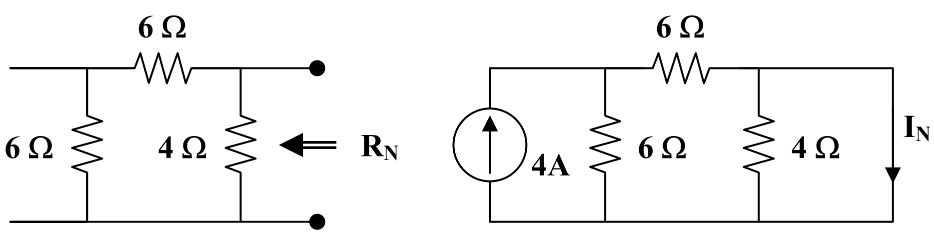
To get $V_{Th}$, consider the circuit in Fig. (d). At the node, KCL gives,

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

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

**Chapter 4, Solution 45.**

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




**(a)** **(b)**

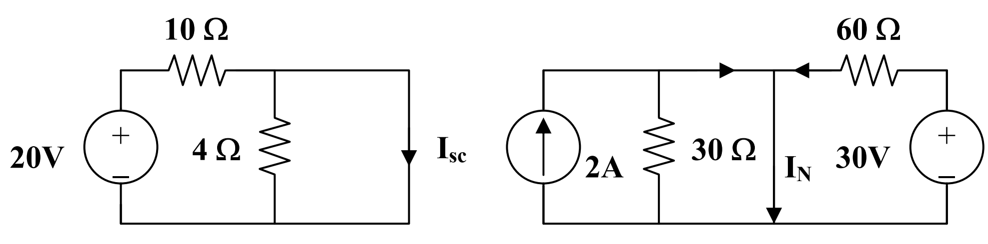
$$R_N = (6 + 6)||4 = 3 \text{ ohms}$$

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,

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

**Chapter 4, Solution 46.**

(a) $R_N = R_{Th} = \underline{\textbf{8 ohms}}$. To find $I_N$, consider the circuit in Fig. (a).




**(a)** **(b)**

$$I_N = I_{sc} = 20/10 = \underline{\textbf{2 A}}$$

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

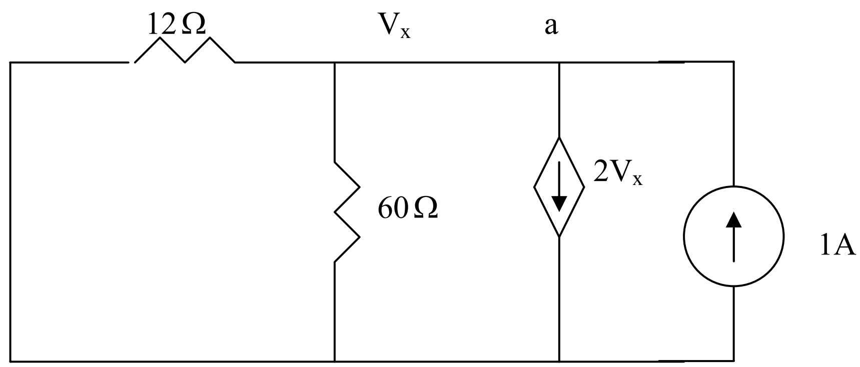
$I_N = I_{sc} = 2 + 30/60 = \underline{\textbf{2.5 A}}$

**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

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

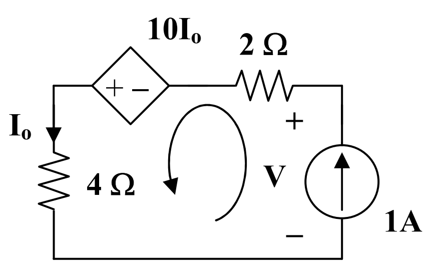
$$R_{Th} = \frac{V_x}{1} = 0.4762\Omega, \quad I_N = \frac{V_{Th}}{R_{Th}} = 1.19/0.4762 = 2.5$$

Thus,

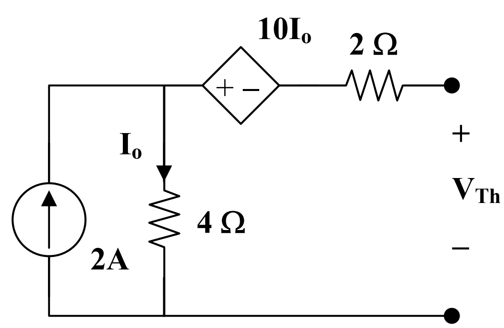
$$\underline{V_{Th} = 1.19V, \quad R_{Th} = R_N = 0.4762\Omega, \quad I_N = 2.5\text{ A}}$$

**Chapter 4, Solution 48.**

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




**(a)**




**(b)**

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

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

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

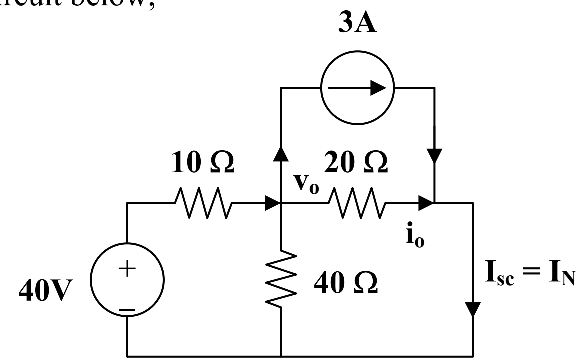
$$I_o = 2, \ V_{Th} = -10I_o + 4I_o = -12 \text{ V}$$

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

**Chapter 4, Solution 49.**

$$R_N = R_{Th} = \underline{\mathbf{28\ ohms}}$$

To find $I_N$, consider the circuit below,

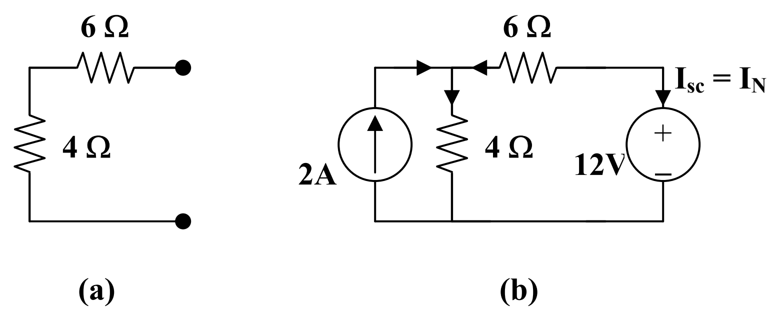



At the node, $(40 - v_o)/10 = 3 + (v_o/40) + (v_o/20)$, or $v_o = 40/7$

$i_o = v_o/20 = 2/7$, but $I_N = I_{sc} = i_o + 3 = \underline{\mathbf{3.286\ A}}$

**Chapter 4, Solution 50.**

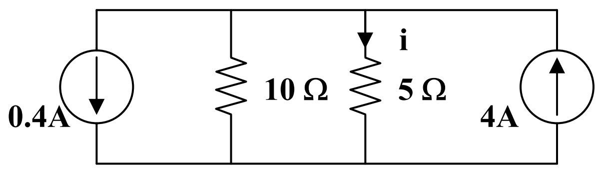
From Fig. (a), $R_N = 6 + 4 = \underline{\mathbf{10\ ohms}}$




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

$$-I_N = (12 - v)/6 = 0.4, \text{ which leads to } I_N = \underline{\mathbf{-0.4\ A}}$$

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



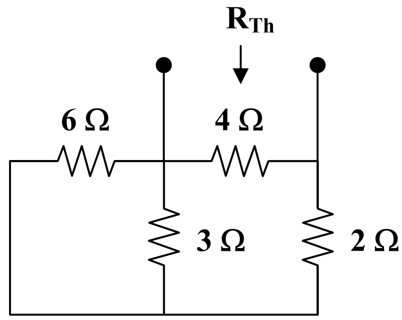

(c)

i = [10/(10 + 5)] (4 – 0.4) = **2.4 A**

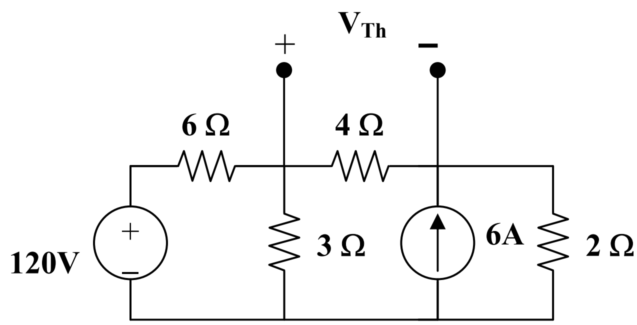
**Chapter 4, Solution 51.**

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

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

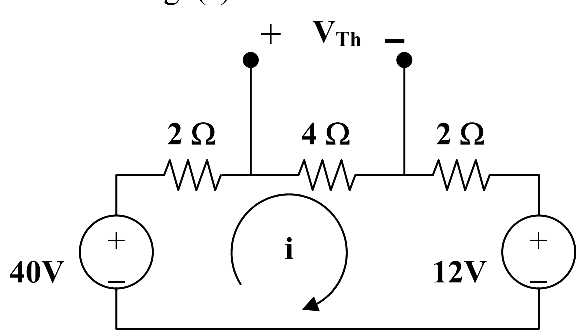



(a)




(b)

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




(c)

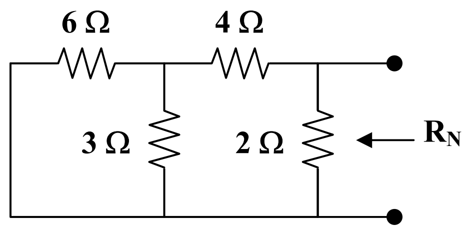
Applying KVL to the circuit in Fig. (c),

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

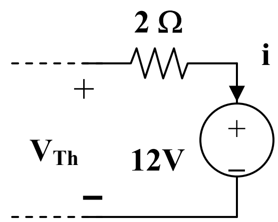
$$V_{Th} = 4i = 14 \text{ therefore } I_N = V_{Th}/R_N = 14/2 = \underline{\textbf{7 A}}$$

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

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




(d)



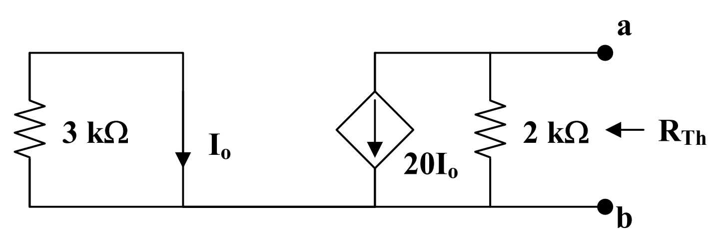

(e)

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

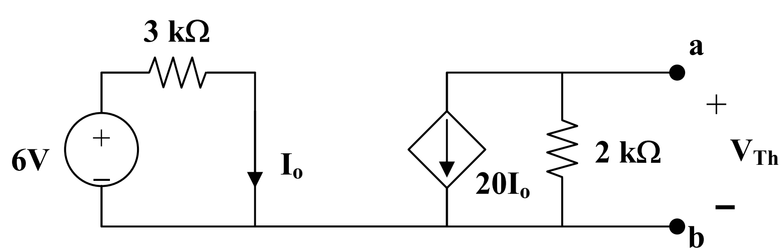
$$i = 7/2, \quad V_{Th} = 12 + 2i = 19, \quad I_N = V_{Th}/R_N = 19/1.5 = \underline{\mathbf{12.667\ A}}$$

**Chapter 4, Solution 52.**

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




(a)




(b)

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

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

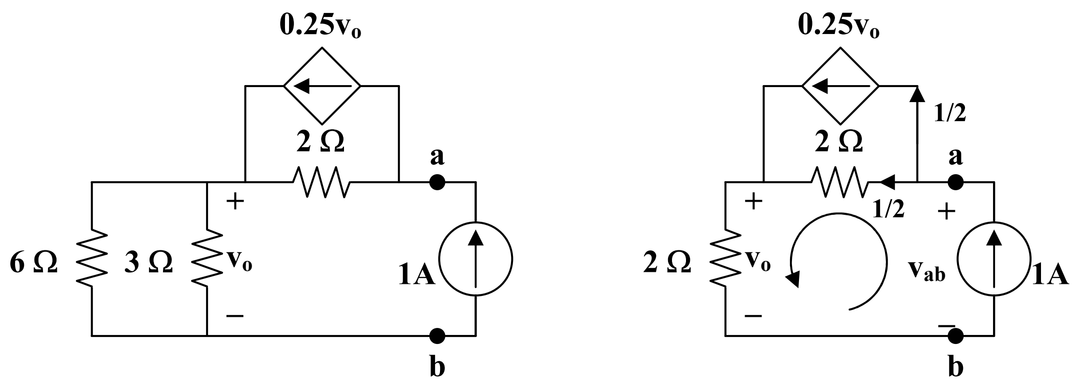
For $V_{Th}$, consider the circuit in Fig. (b).

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

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

**Chapter 4, Solution 53.**

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



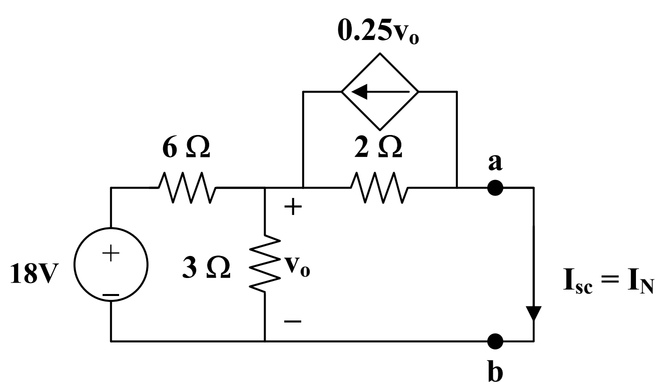

From Fig. (b),

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

$$v_{ab} = 3V$$

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

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

**Chapter 4, Solution 54**

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

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

For the right loop,

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

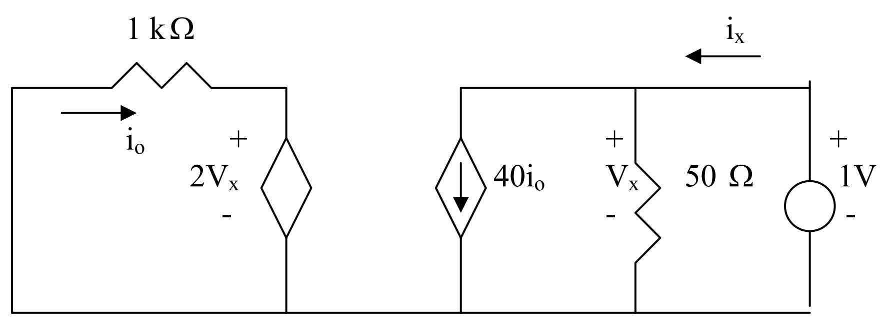
Combining (1) and (2),

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

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

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

.



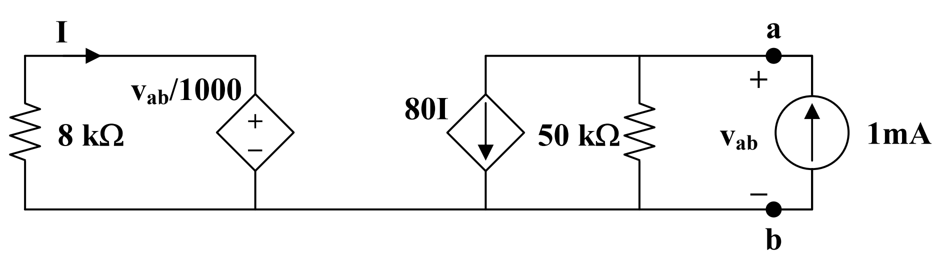

$$V_x = 1, \quad i_o = -\frac{2V_x}{1000} = -2\text{mA}$$

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

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

**Chapter 4, Solution 55.**

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




**(a)**

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

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

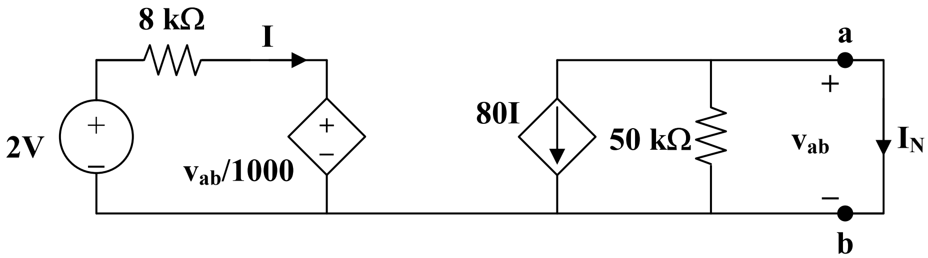
Also,

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

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

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

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




(b)

Since the 50-k ohm resistor is shorted,

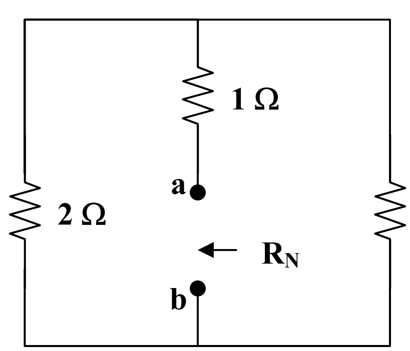
$$I_N = -80I, \; v_{ab} = 0$$

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

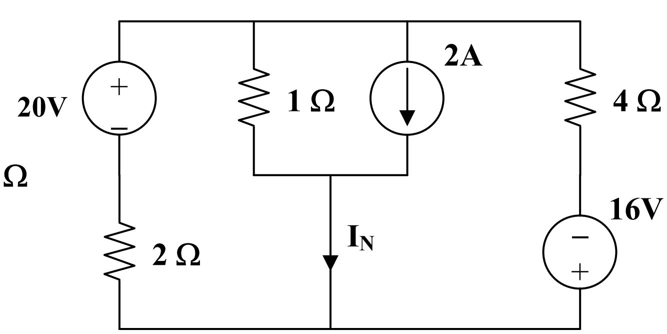
$$I_N = \underline{\mathbf{-20\ mA}}$$

**Chapter 4, Solution 56.**

We first need $R_N$ and $I_N$.




(a)

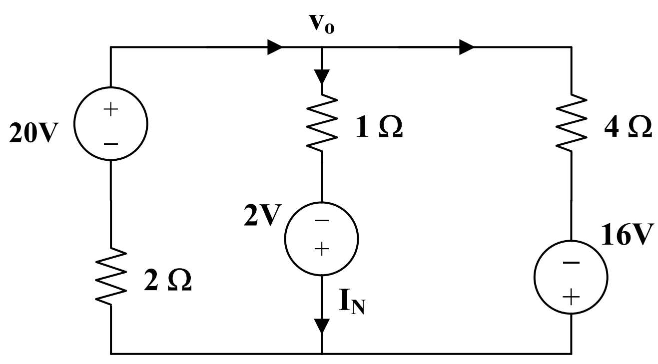



(b)

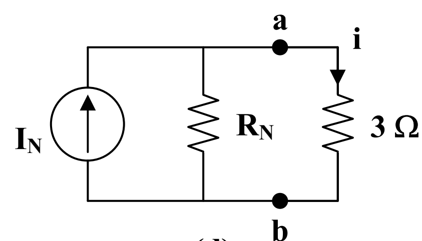
To find $R_N$, consider the circuit in Fig. (a).

$$R_N = 1 + 2||4 = (7/3) \text{ ohms}$$

To get $I_N$, short-circuit ab and find $I_{sc}$ from the circuit in Fig. (b). The current source can be transformed to a voltage source as shown in Fig. (c).




(c)




(d)

$$(20 - v_o)/2 = [(v_o + 2)/1] + [(v_o + 16)/4], \text{ or } v_o = 16/7$$

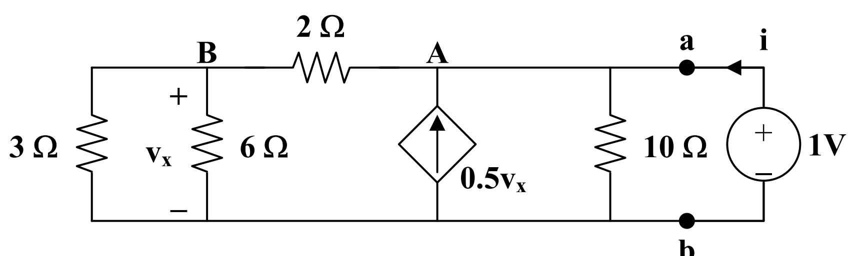
$$I_N = (v_o + 2)/1 = 30/7$$

From the Norton equivalent circuit in Fig. (d),

$$i = R_N/(R_N + 3), \; I_N = [(7/3)/((7/3) + 3)](30/7) = 30/16 = \underline{\mathbf{1.875\ A}}$$

**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).




(a)

We apply nodal analysis. At node A,

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

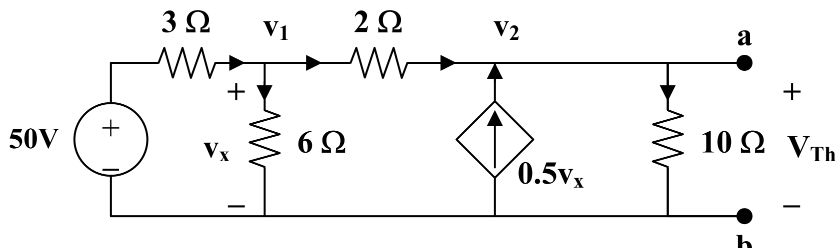
At node B,

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

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

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

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




(b)

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

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

From (3) and (4),

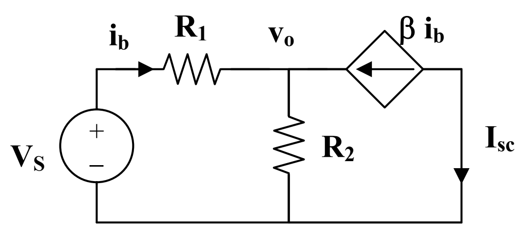
$$v_2 = V_{Th} = \underline{\textbf{166.67 V}}$$

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

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

**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 vo,

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

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

$$v_o = V_s - i_bR_1$$

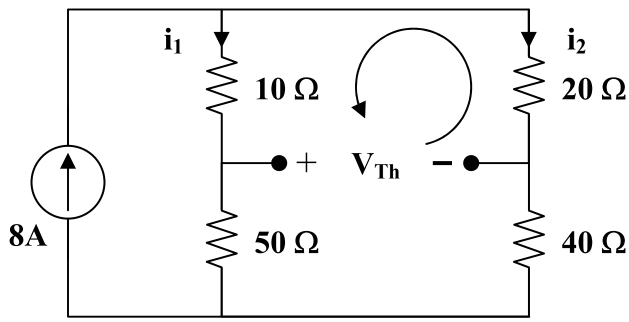
$$V_s - i_bR_1 = (1 + \beta)R_2i_b, \text{ or } i_b = V_s/(R_1 + (1 + \beta)R_2)$$

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

**Chapter 4, Solution 59.**

$R_{Th} = (10 + 20)||(50 + 40) \;\; 30||90 =$ **$\underline{22.5 \text{ ohms}}$**

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

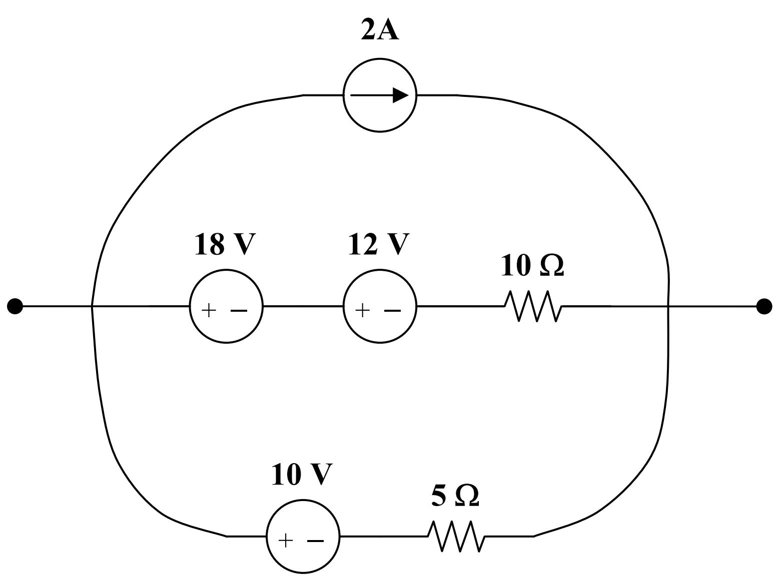


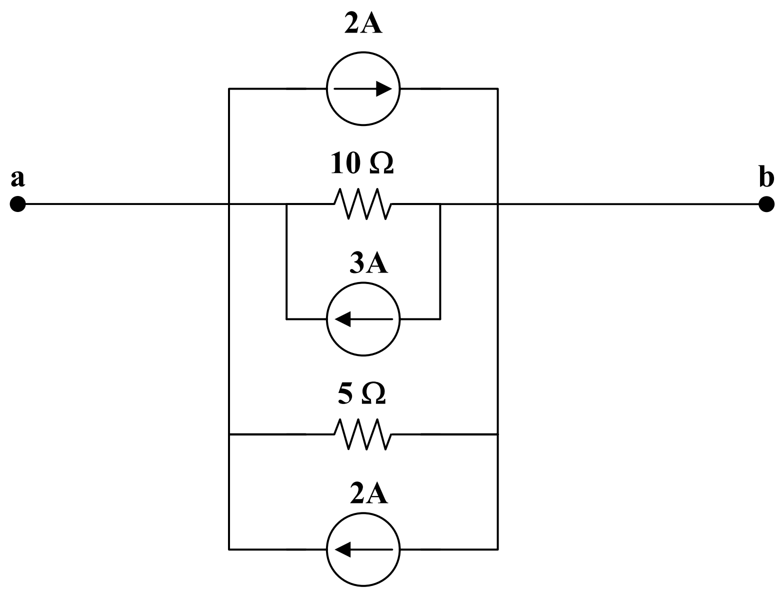

$$i_1 = i_2 = 8/2 = 4, \;\; 10i_1 + V_{Th} - 20i_2 = 0, \text{ or } V_{Th} = 20i_2 - 10i_1 = 10i_1 = 10\text{x}4$$

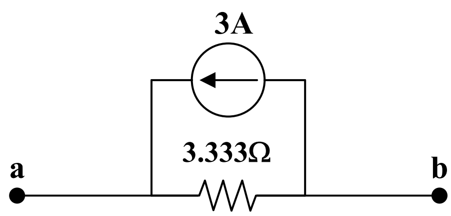
$V_{Th} =$ **$\underline{40V}$**, and $I_N = V_{Th}/R_{Th} = 40/22.5 =$ **$\underline{1.7778 \text{ A}}$**

**Chapter 4, Solution 60.**

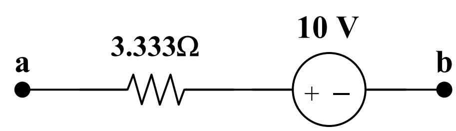
The circuit can be reduced by source transformations.






Norton Equivalent Circuit



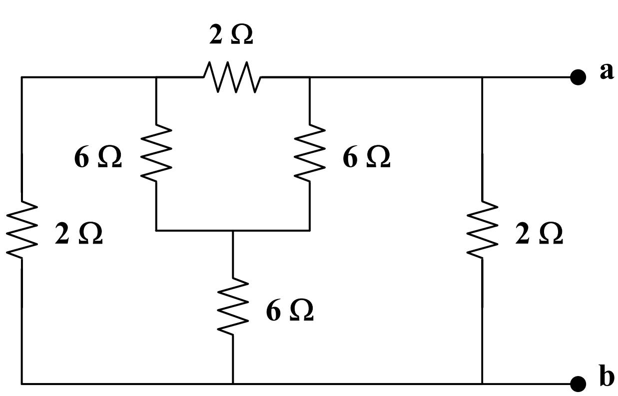

Thevenin Equivalent Circuit

**Chapter 4, Solution 61.**

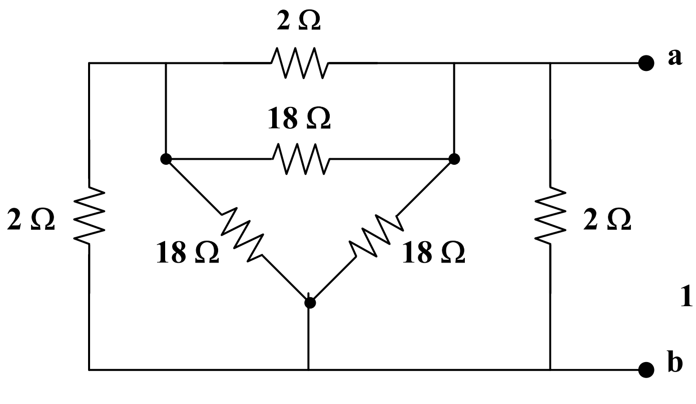
To find $R_{Th}$, consider the circuit in Fig. (a).

Let $R = 2||18 =$ **<u>1.8 ohms</u>**, $R_{Th} = 2R||R = (2/3)R =$ **<u>1.2 ohms</u>**.

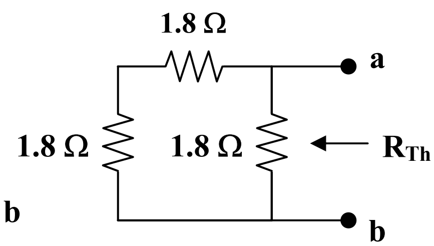
To get $V_{Th}$, we apply mesh analysis to the circuit in Fig. (d).



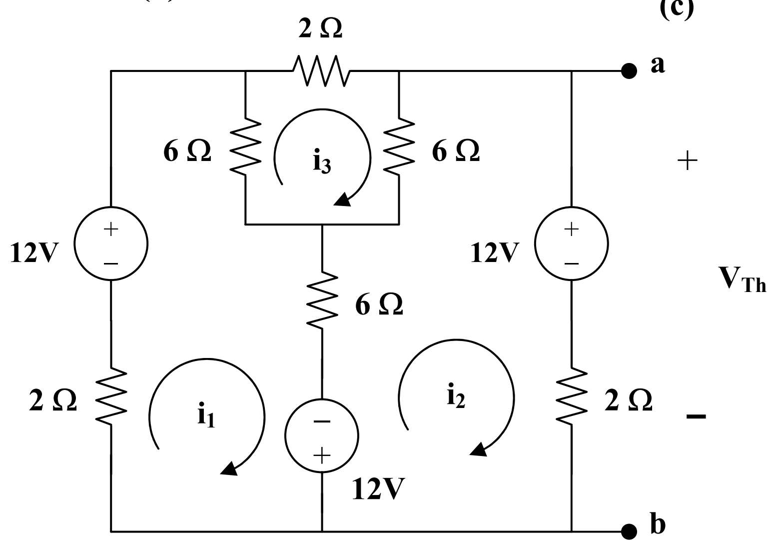

**(a)**




(b)




(c)




(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),

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

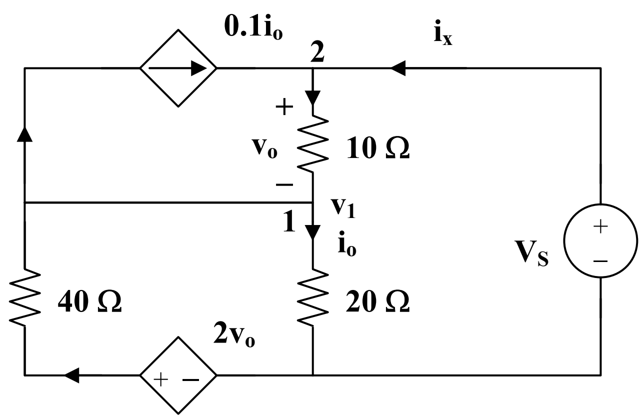
$$\Delta = \begin{vmatrix} 7 & -3 & -3 \\ -3 & 7 & -3 \\ -3 & -3 & 7 \end{vmatrix} = 100, \qquad \Delta_2 = \begin{vmatrix} 7 & 12 & -3 \\ -3 & -12 & -3 \\ -3 & 0 & 7 \end{vmatrix} = -120$$

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

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

**Chapter 4, 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),

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

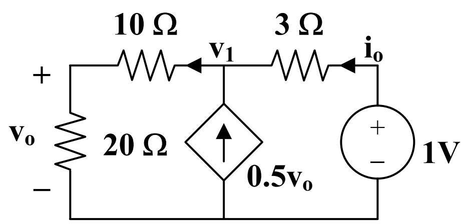
$$10i_x = 1 - v_1 - v_1/20 = 1 - (21/20)v_1 = 1 - (21/20)(6/9.2)$$

$i_x = 31.52$ mA, $R_{Th} = 1/i_x =$ **<u>31.73 ohms.</u>**

**Chapter 4, Solution 63.**

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

$R_N$ can be found using the circuit below.



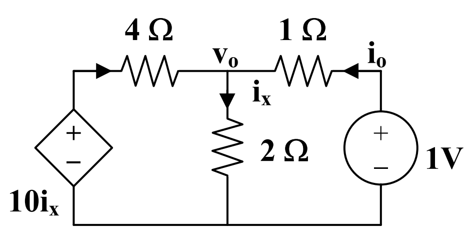

Applying KCL at node 1, $0.5v_o + (1 - v_1)/3 = v_1/30$, but $v_o = (20/30)v_1$

Hence, $0.5(2/3)(30)v_1 + 10 - 10v_1 = v_1$, or $v_1 = 10$ and $i_o = (1 - v_1)/3 = -3$

$R_N = 1/i_o = -1/3 =$ **-333.3 m ohms**

**Chapter 4, Solution 64.**

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




$$i_x = [(1 - v_o)/1] + [(10i_x - v_o)/4], \text{ or } 2v_o = 1 + 3i_x \quad (1)$$

But $i_x = v_o/2$. Hence,

$$2v_o = 1 + 1.5v_o, \text{ or } v_o = 2, \; i_o = (1 - v_o)/1 = -1$$

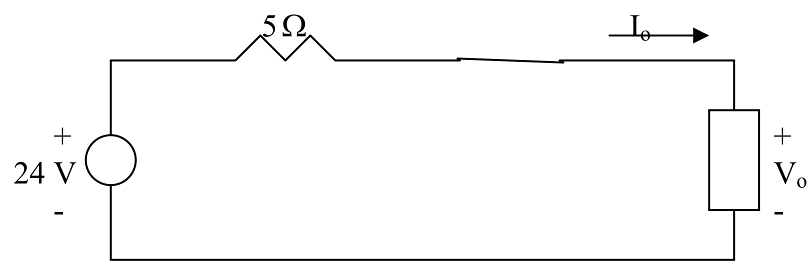
Thus, $R_{Th} = 1/i_o =$ **-1 ohm**

**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.

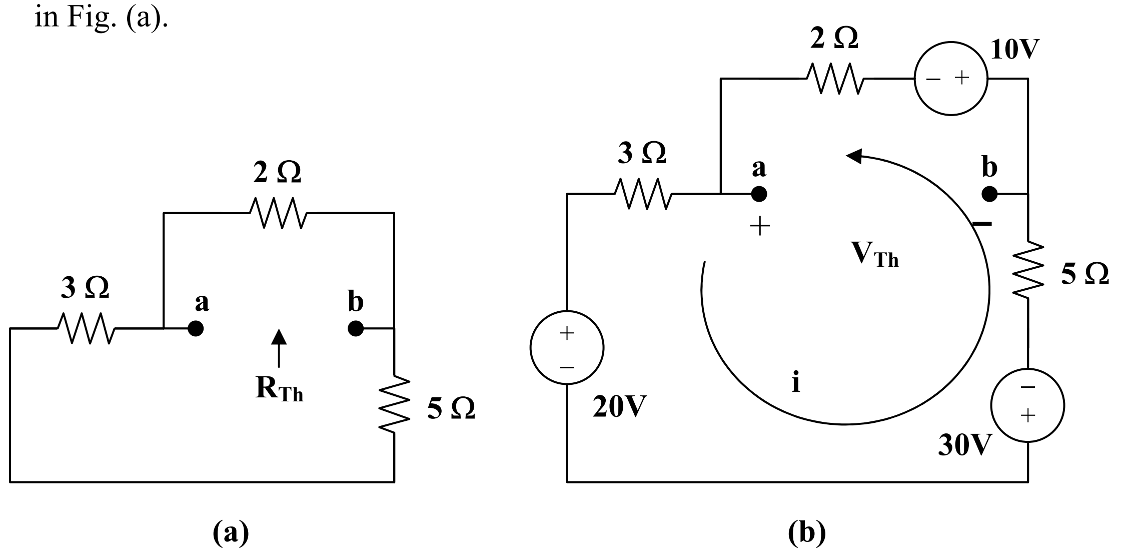



Applying KVL to the loop,

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

**Chapter 4, 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 $V_{Th}$.

$$10i + 30 + 20 + 10 = 0, \text{ or } i = -5$$

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

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

**Chapter 4, Solution 67.**

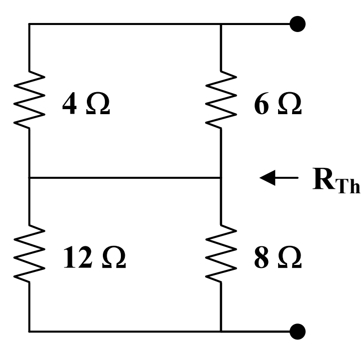
We need to find the Thevenin equivalent at terminals a and b.

From Fig. (a),

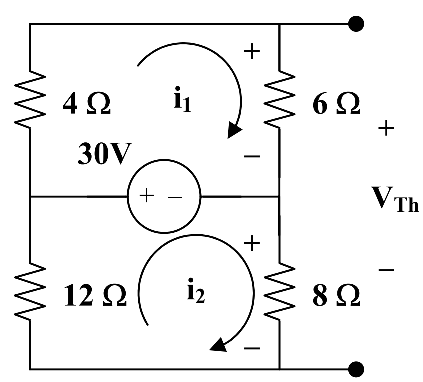
$$R_{Th} = 4||6 + 8||12 = 2.4 + 4.8 = \underline{\textbf{7.2 ohms}}$$

From Fig. (b),

$$10i_1 - 30 = 0, \text{ or } i_1 = 3$$




(a)




(b)

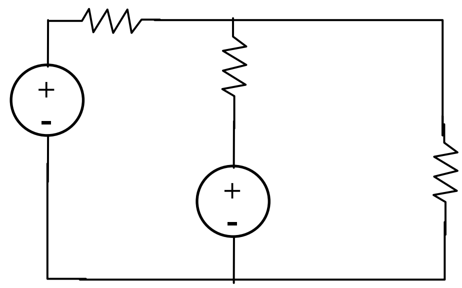
$$20i_2 + 30 = 0, \text{ or } i_2 = 1.5, \ V_{Th} = 6i_1 + 8i_2 = 6x3 - 8x1.5 = \underline{\textbf{6 V}}$$

For maximum power transfer,

$$p = V_{Th}^2/(4R_{Th}) = (6)^2/[4(7.2)] = \underline{\textbf{1.25 watts}}$$

**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.

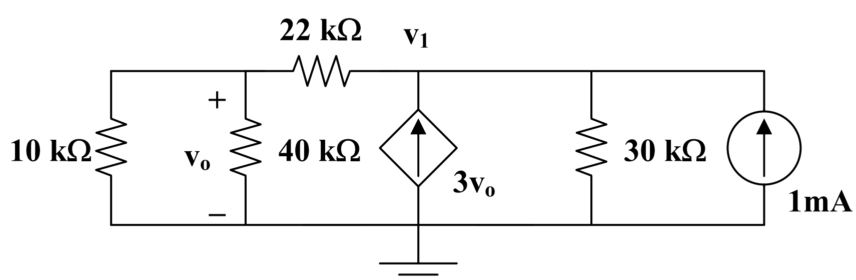
$$P = vi = v^2/R = 4x4/10 = 1.6 \text{ watts}$$

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, 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.

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

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

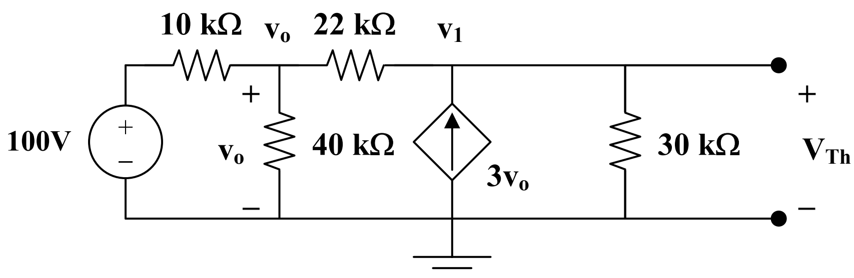
$$15 + 45v_o = v_1$$

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

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

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

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




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

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

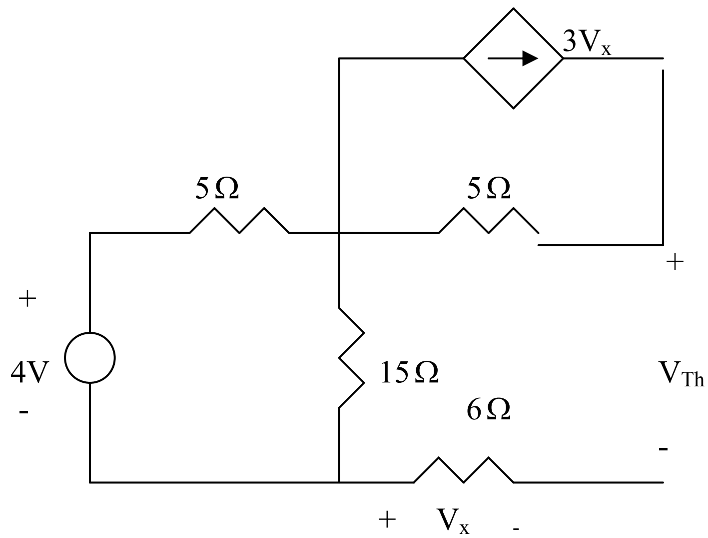
Solving (1) and (2),

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

$p = V_{Th}^2/(4R_{Th}) = (243.6)2/[4(-1363.6)] =$ **<u>-10.882 watts</u>**

**Chapter 4, Solution 70**

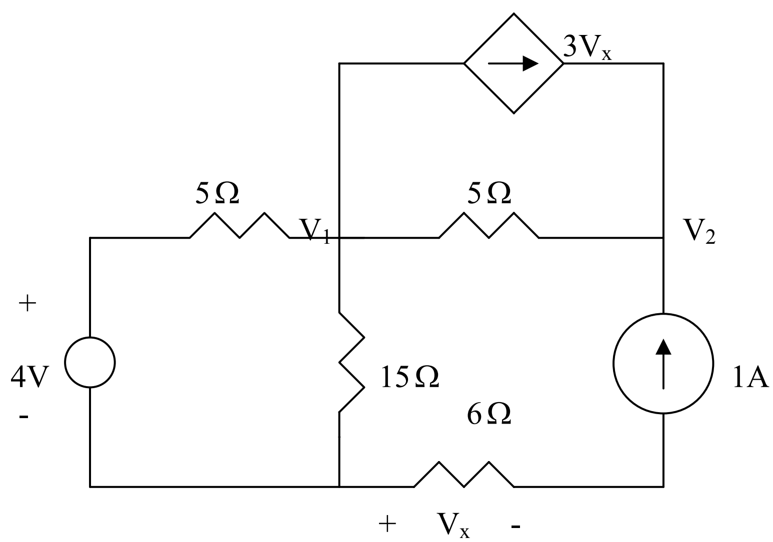
We find the Thevenin equivalent across the 10-ohm resistor. To find $V_{Th}$, consider the circuit below.




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,

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

At node 2,

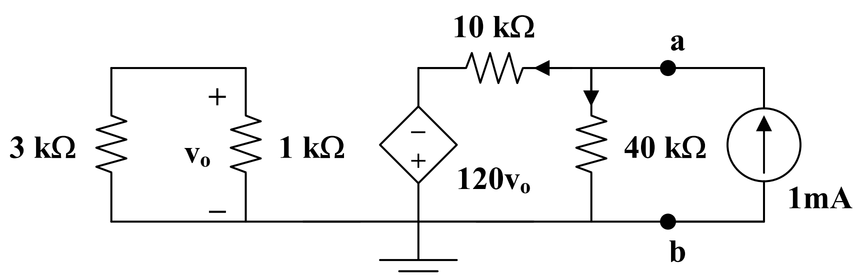
$$1 + 3V_x + \frac{V_1 - V_2}{5} = 0 \quad \longrightarrow \quad V_1 = V_2 - 95 \qquad (2)$$

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, 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

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

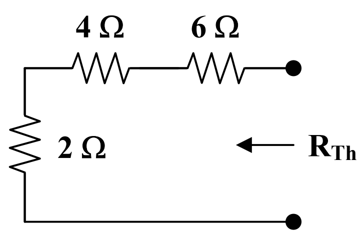
$$p = V_{Th}^2/(4R_{Th}) = (-192)^2/(4x8x10^3) = \underline{\mathbf{1.152\ watts}}$$

**Chapter 4, Solution 72.**

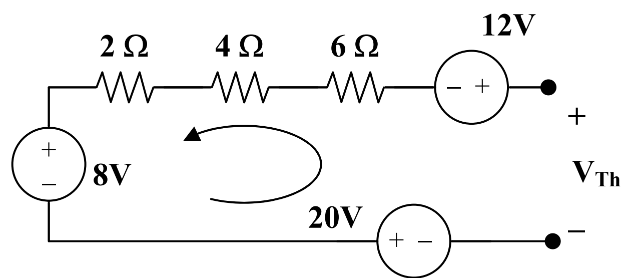
(a) $R_{Th}$ and $V_{Th}$ are calculated using the circuits shown in Fig. (a) and (b) respectively.

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

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




**(a)**




**(b)**

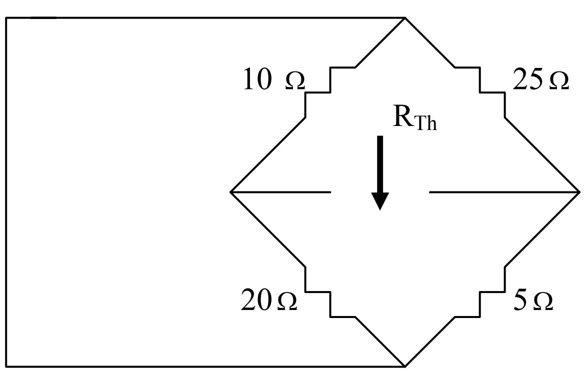
(b) $i = V_{Th}/(R_{Th} + R) = 40/(12 + 8) = \underline{\mathbf{2A}}$

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

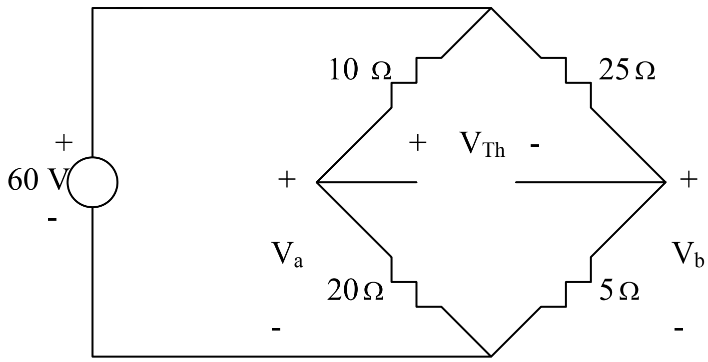
(d) $p = V_{Th}^2/(4R_{Th}) = (40)^2/(4\text{x}12) = \underline{\mathbf{33.33\ watts}}$.

**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, 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,

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

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

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

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

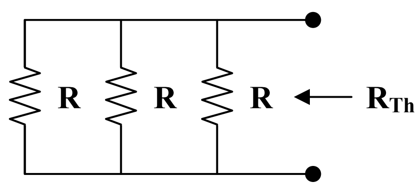
where $a = (R_1 R_2 R_3 + R_1 R_2 R_4 + R_1 R_3 R_4 + R_2 R_3 R_4)$

$$p_{max} =$$

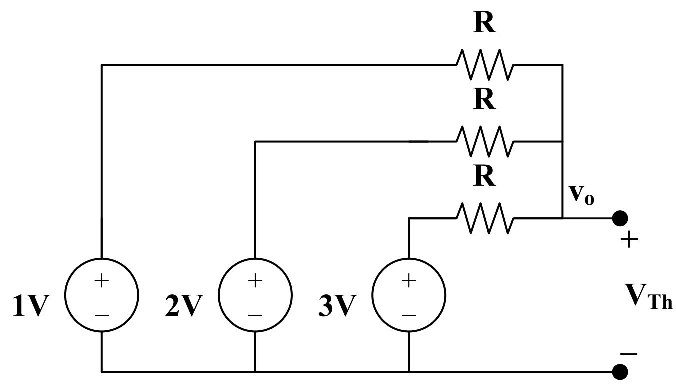
$$\underline{\mathbf{[(R_2R_3) - (R_1R_4)]^2V_s^2/[4(R_1 + R_2)(R_3 + R_4)(R_1 R_2 R_3 + R_1 R_2 R_4 + R_1 R_3 R_4 + R_2 R_3 R_4)]}}$$

**Chapter 4, Solution 75.**

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




(a)




(b)

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,

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

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

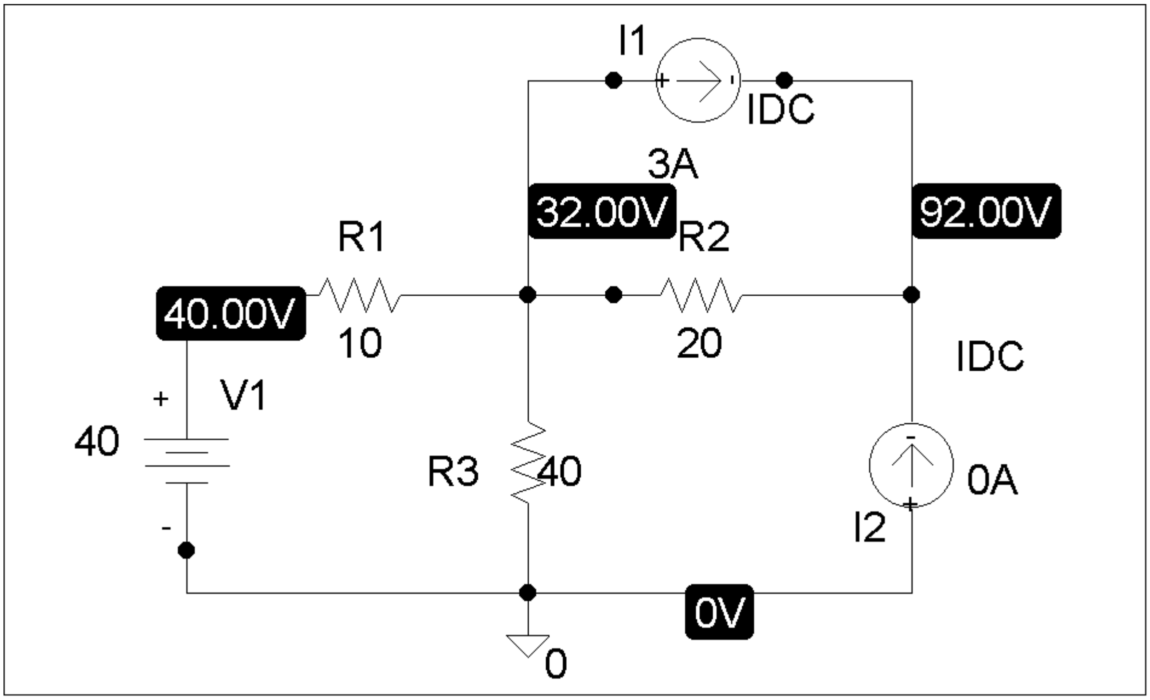
$$R_{Th} = [(V_{Th})^2/(4P_{max})] = 4/(4xP_{max}) = 1/P_{max} = R/3$$

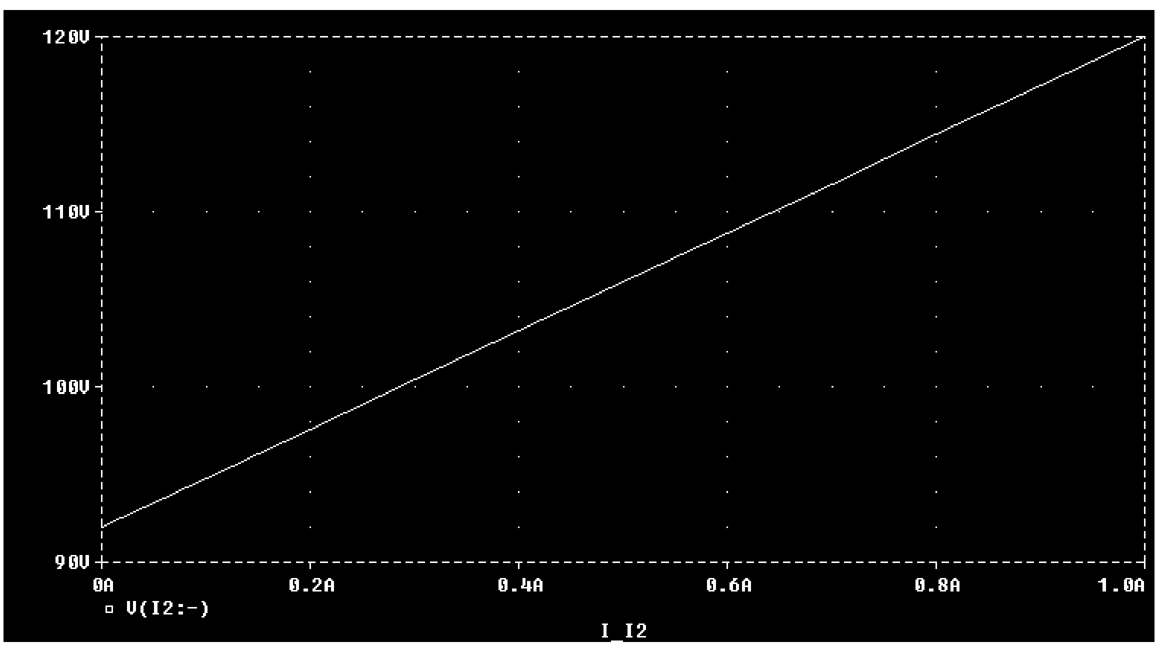
$$R = 3/(3x10^{-3}) = \underline{\textbf{1 k ohms}}$$

**Chapter 4, Solution 76.**

Follow the steps in Example 4.14. The schematic and the output plots are shown below. From the plot, we obtain, V = **92 V** [i = 0, voltage axis intercept]

R = Slope = (120 – 92)/1 = **28 ohms**



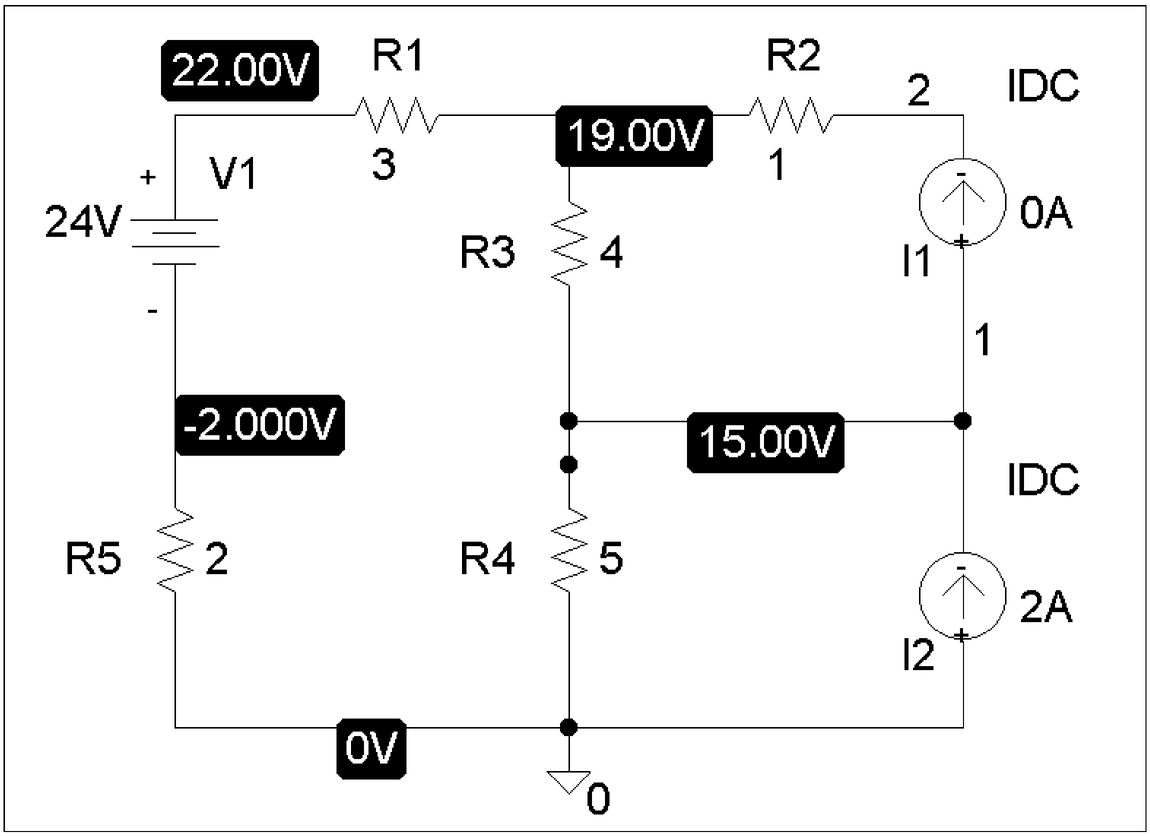



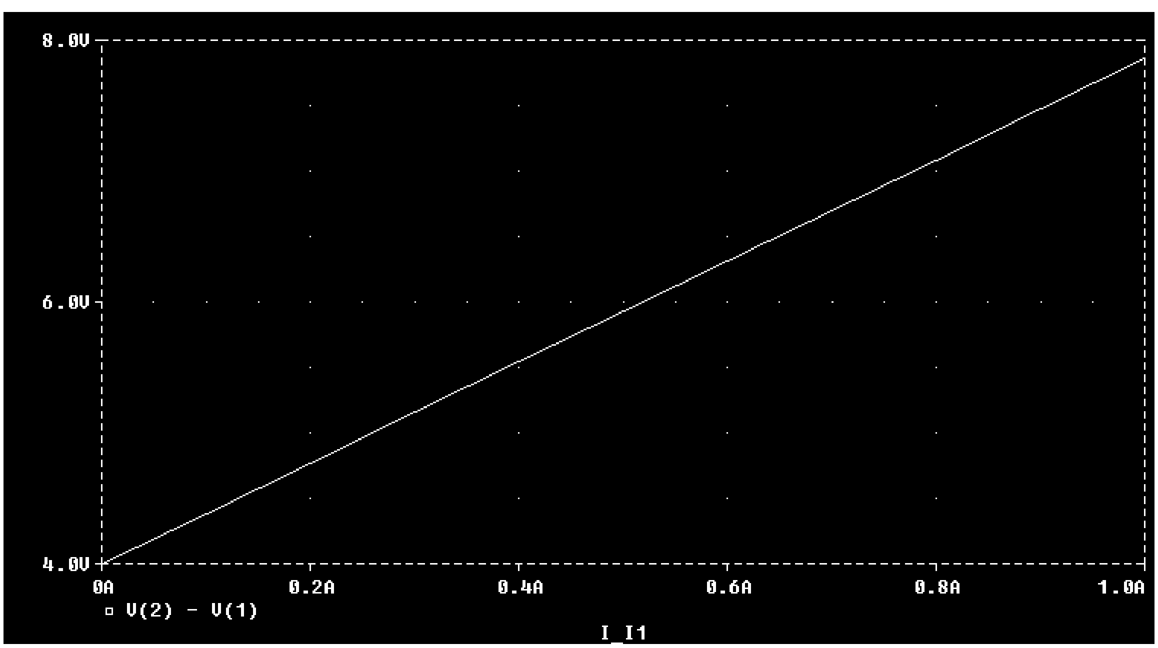
**Chapter 4, Solution 77.**

(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.

$$V_{Th} = \underline{\textbf{4 V}} \text{ [zero intercept]}$$

$$R_{Th} = (7.8 - 4)/1 = \underline{\textbf{3.8 ohms}}$$

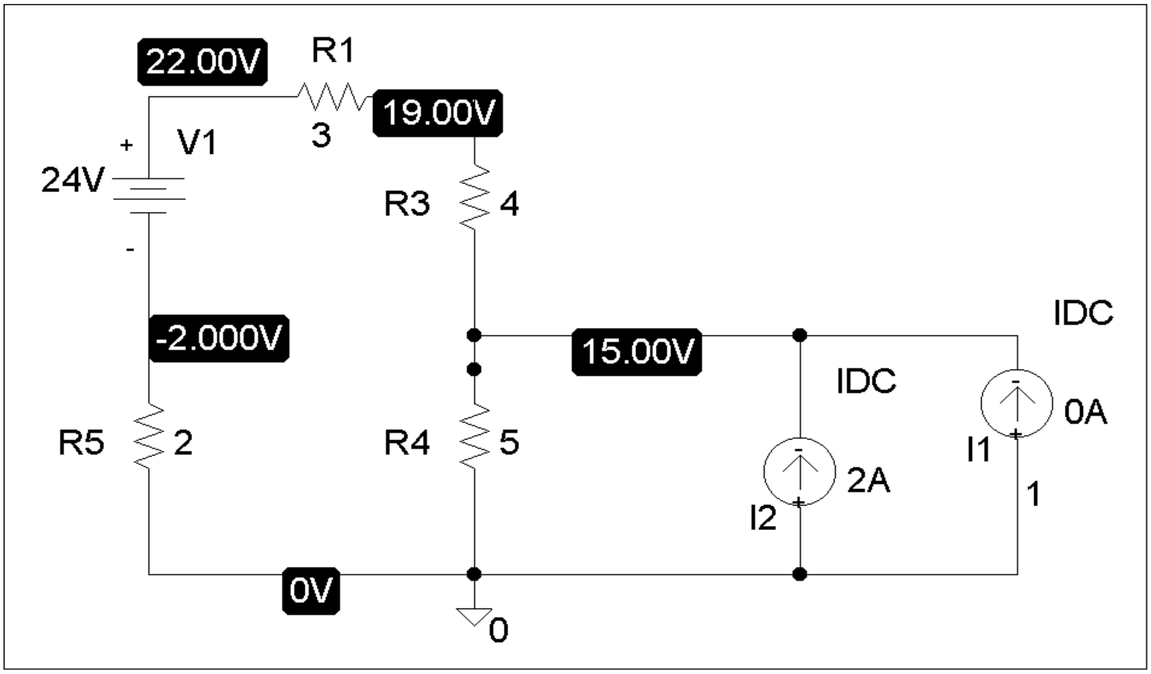


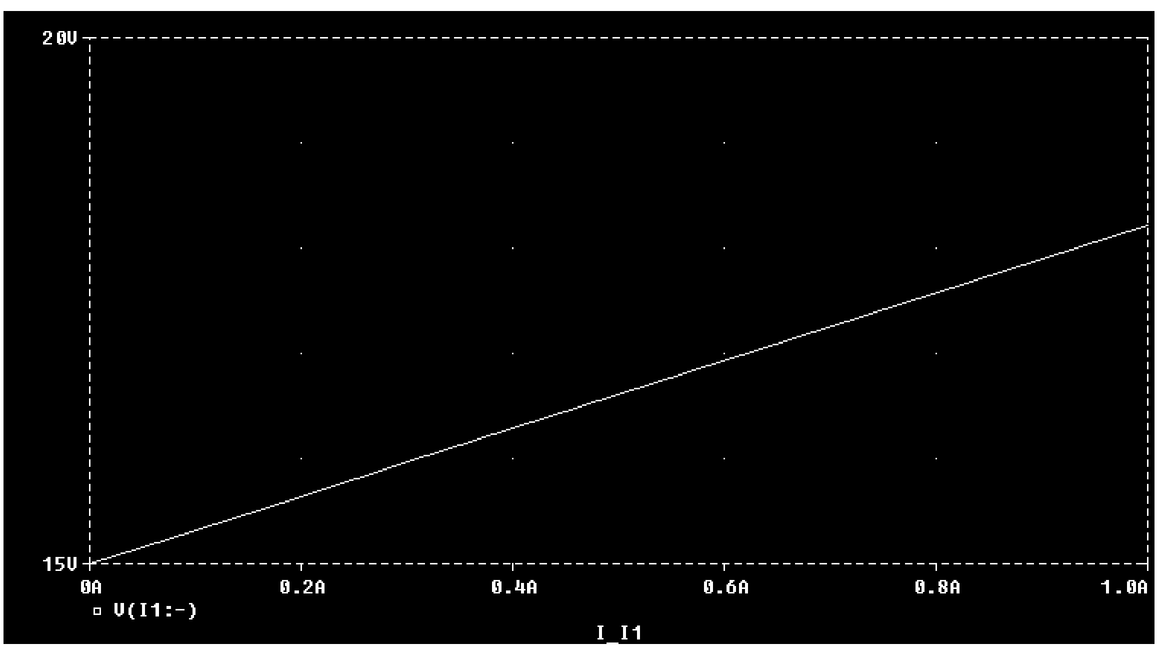



(b) Everything remains the same as in part (a) except that the current source, I1, is connected between terminals b and c as shown below. We perform a dc sweep on I1 and obtain the plot shown below. From the plot, we obtain,

$$V = \underline{\mathbf{15\ V}} \text{ [zero intercept]}$$

$$R = (18.2 - 15)/1 = \underline{\mathbf{3.2\ ohms}}$$



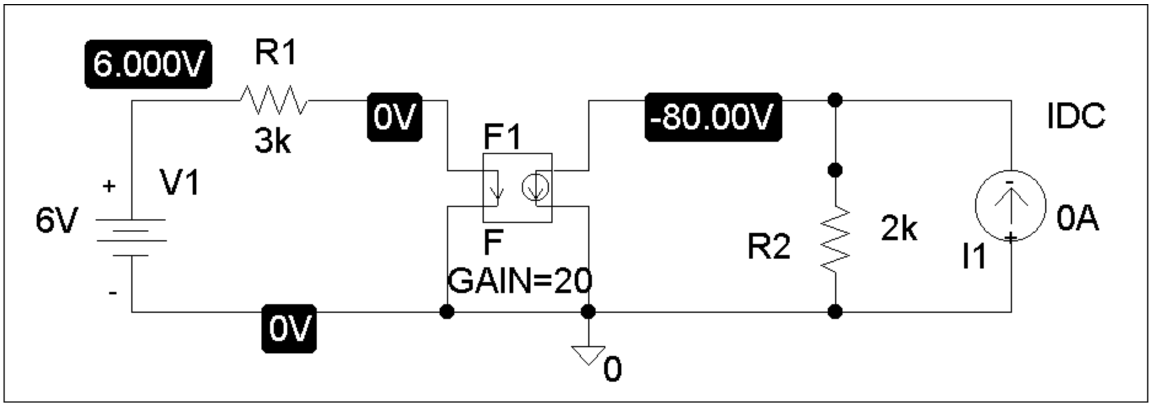



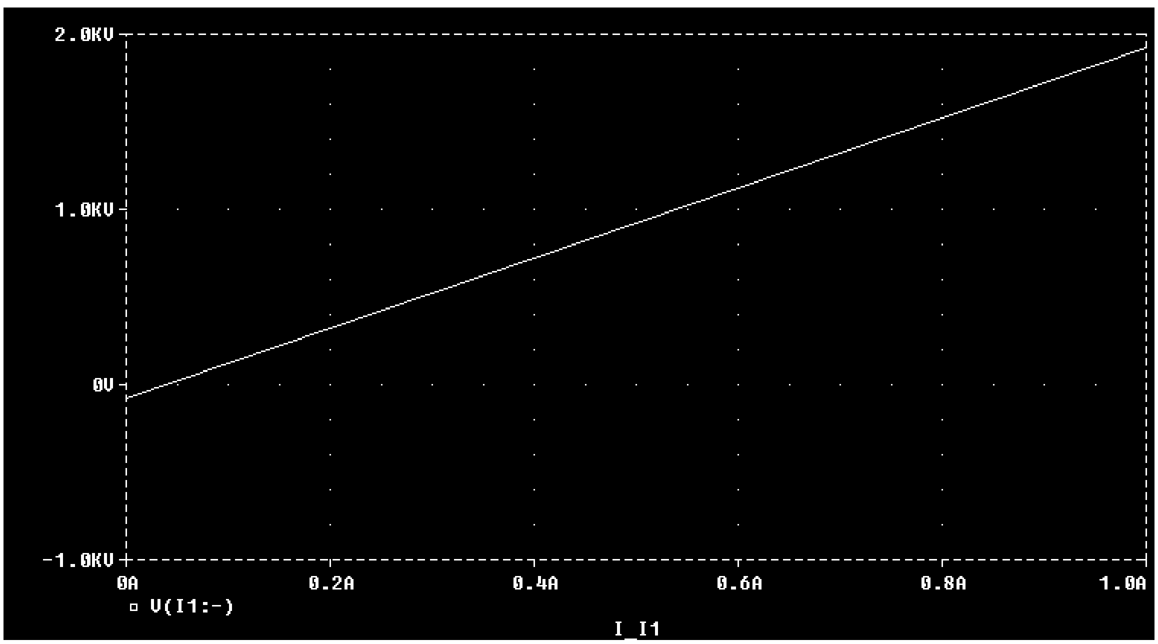
**Chapter 4, Solution 78.**

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,

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

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



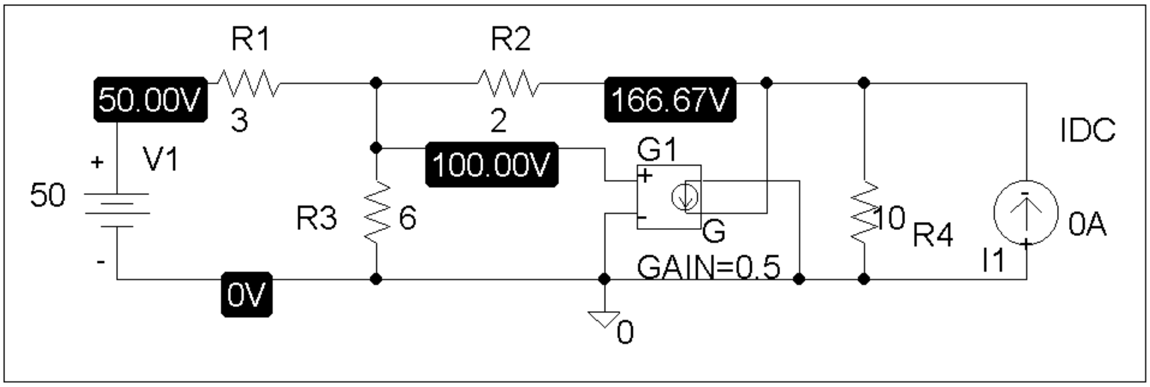



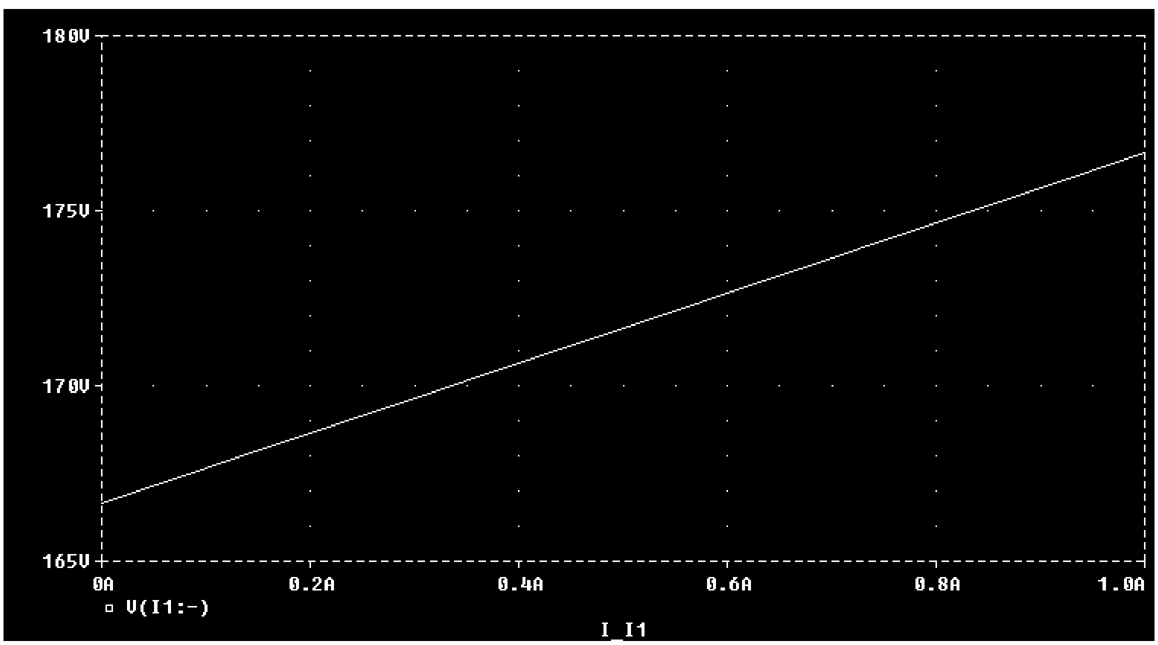
**Chapter 4, Solution 79.**

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 = **<u>167 V</u>** [zero intercept]

R = (177 – 167)/1 = **<u>10 ohms</u>**



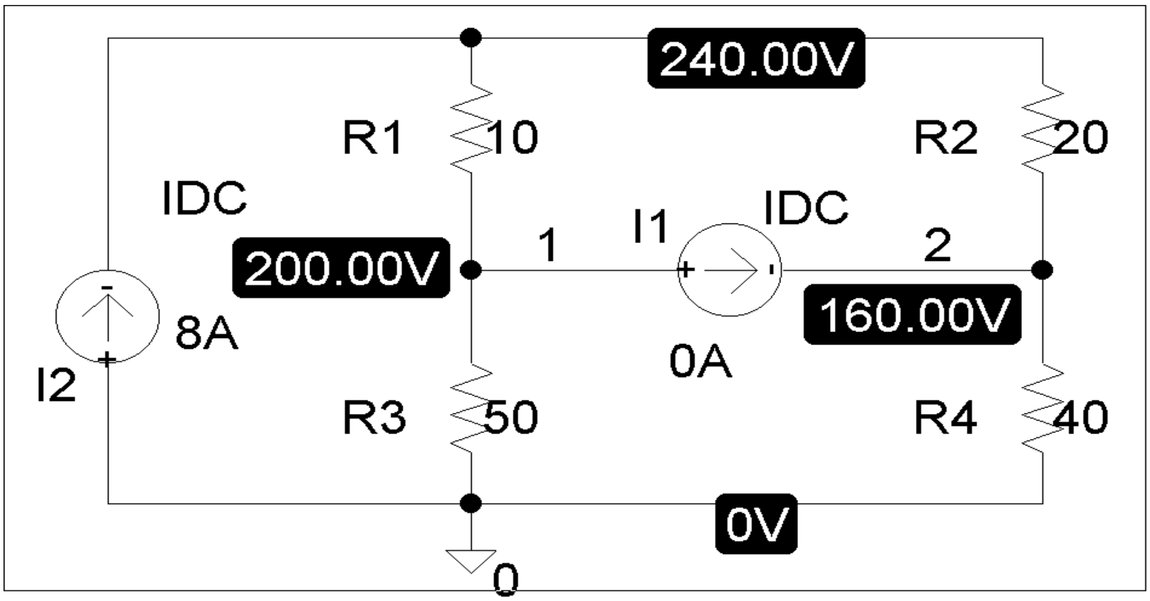



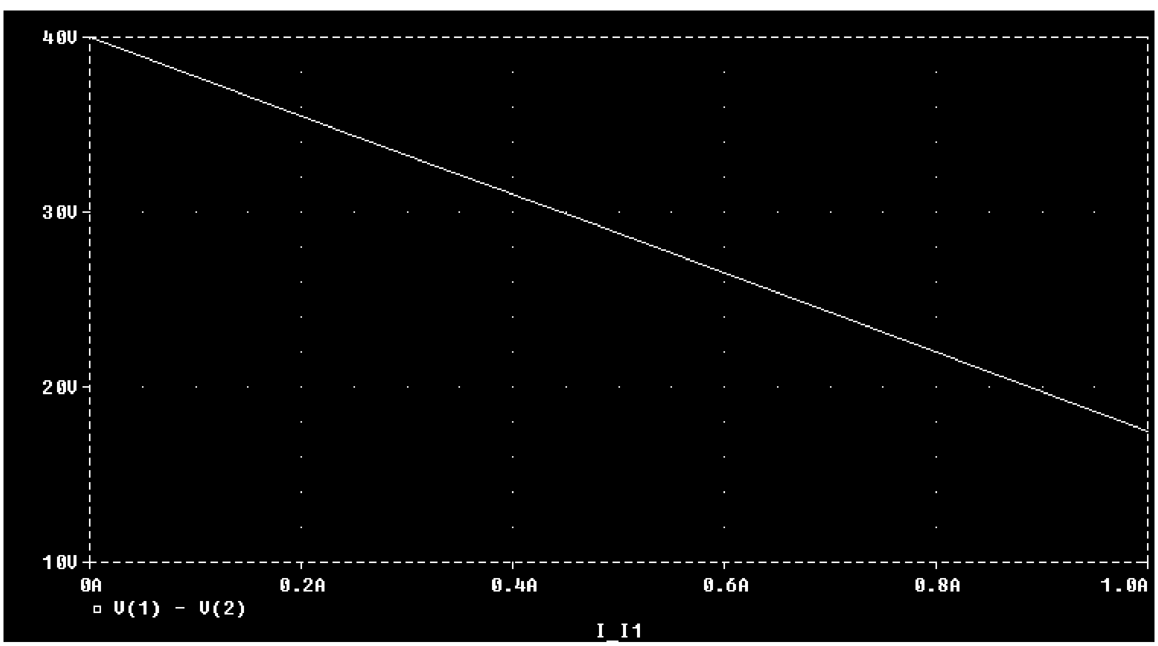
**Chapter 4, Solution 80.**

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,

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

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



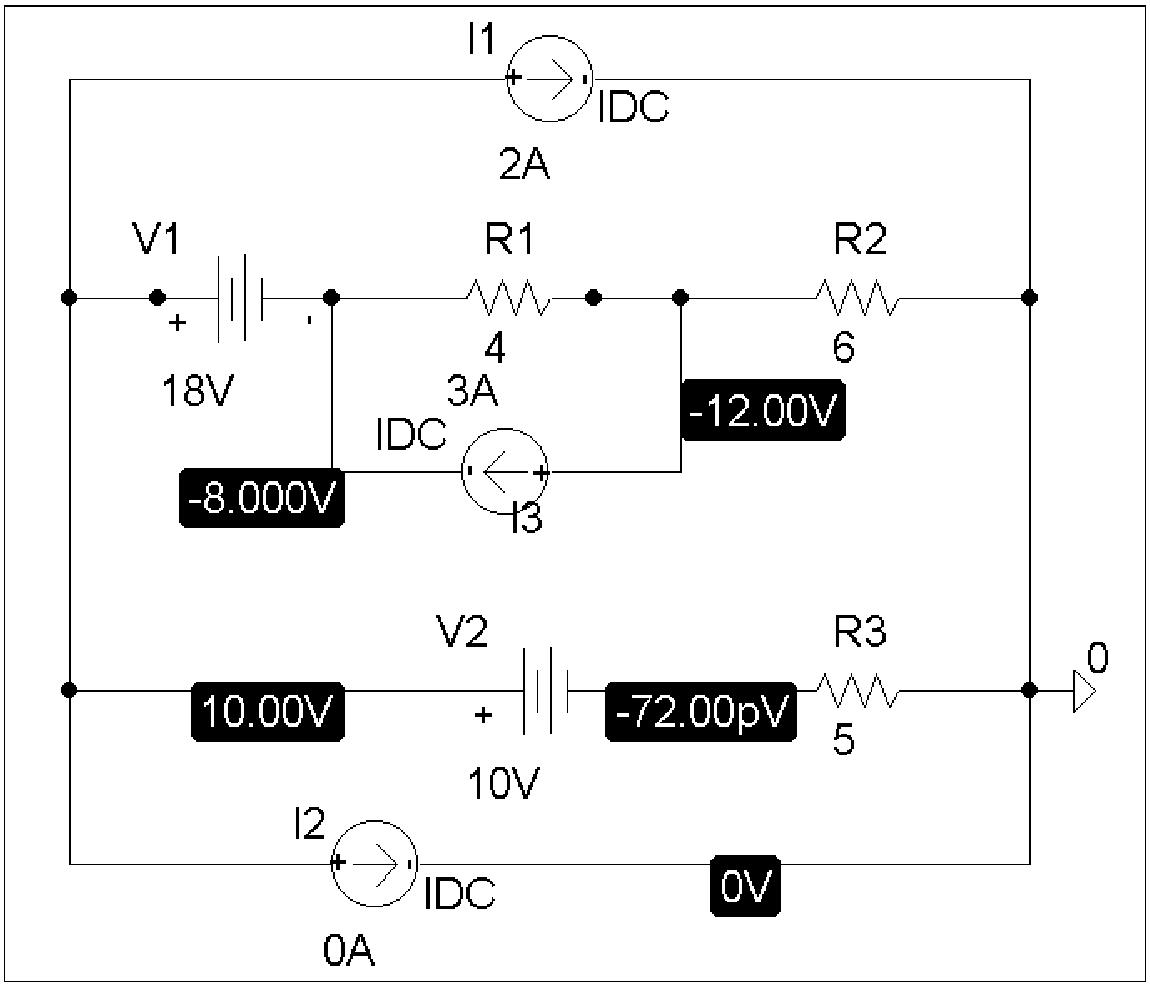



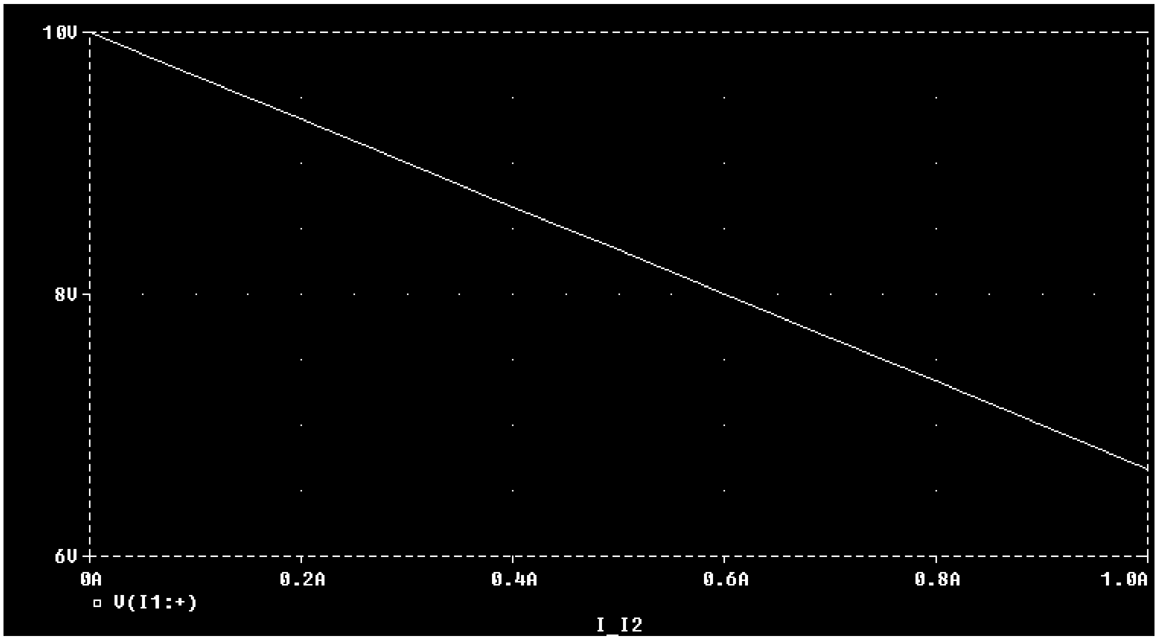
**Chapter 4, Solution 81.**

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,

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

$$R_{Th} = (10 - 6.4)/1 = \underline{\textbf{3.4 ohms}}.$$

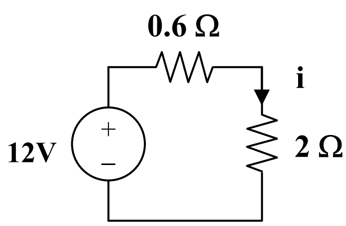





**Chapter 4, Solution 82.**

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

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




$i = 12/2.6$, $p = i^2R = (12/2.6)^2(2) =$ **<u>42.6 watts</u>**

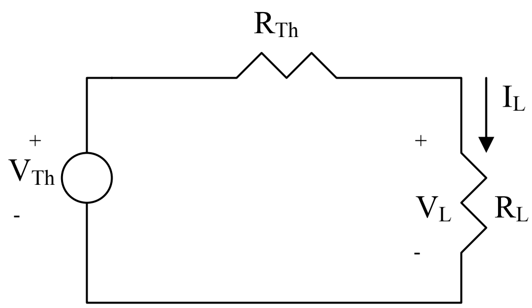
**Chapter 4, Solution 83.**

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

$R_{Th} = V_{Th}/I_N = 8$ ohms, $V_{Th} =$ **<u>12 V</u>**, $R_{Th} =$ **<u>8 ohms</u>**

**Chapter 4, Solution 84**

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




For open circuit,

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

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

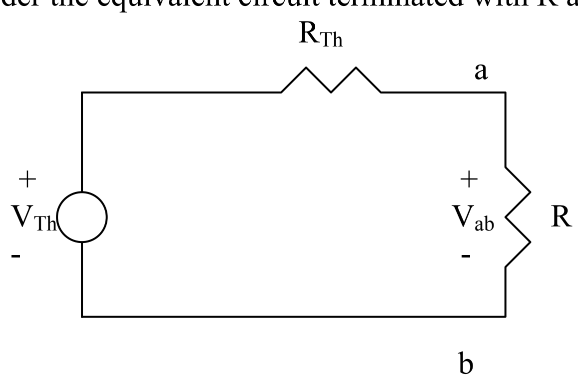
$$I_L = \frac{V_L}{R_L} = 10.8/4 = 2.7$$

But

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

**Chapter 4, Solution 85**

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




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

or

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

where $R_{Th}$ is in k-ohm.

Similarly,

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

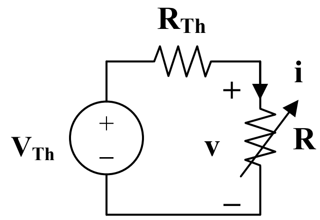
Solving (1) and (2) leads to

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

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

**Chapter 4, 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.

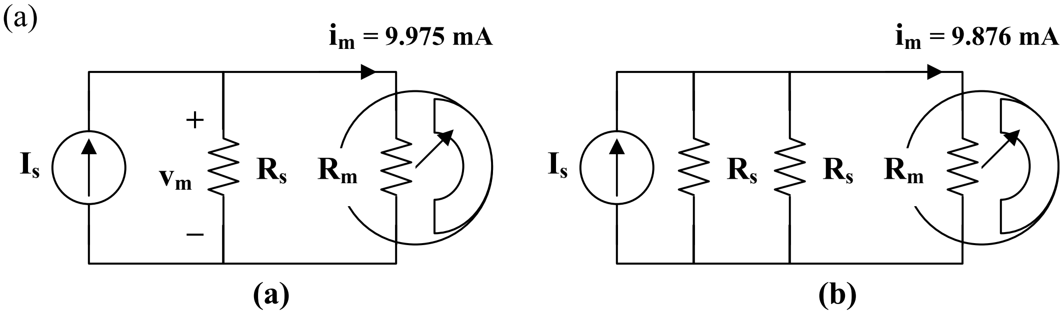
(a) When R = 4, i = $V_{Th}/(R + R_{Th})$ = 18/(4 + 10) = **1.2857 A**

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

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

**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),

$$v_m = R_m i_m = 20\text{x}9.876 = 0.19752 \text{ V}$$

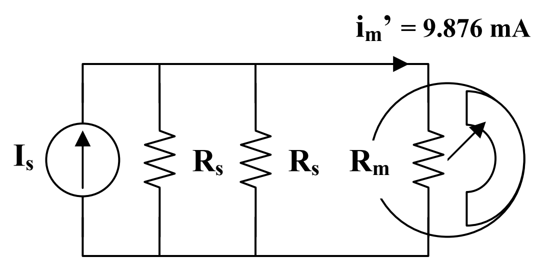
$$I_s = 9.876 \text{ mA} + (0.19752/2\text{k}) + (0.19752/R_s)$$

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

Solving (1) and (2) gives,

$R_s$ = **8 k ohms**, $I_s$ = **10 mA**

(b)



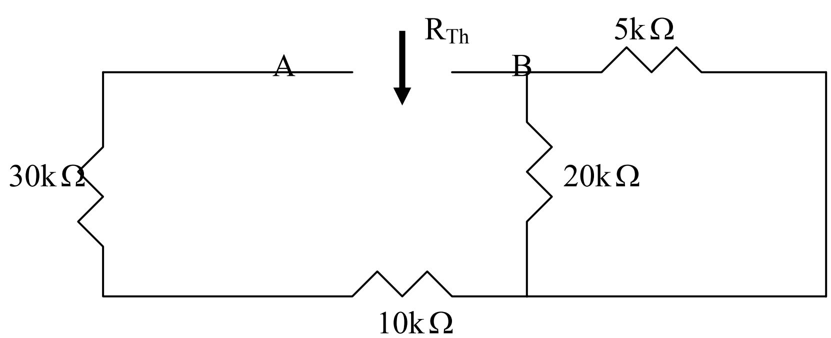

**(b)**

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

$i_m'$ = [2667/(2667 + 20)](10 mA) = **9.926 mA**

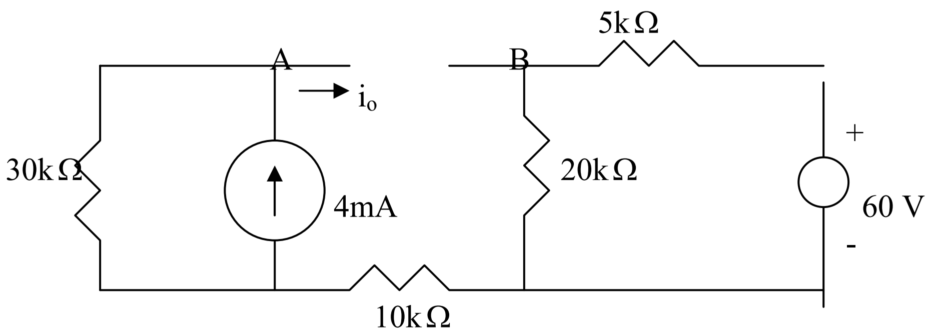
**Chapter 4, Solution 88**

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




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

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

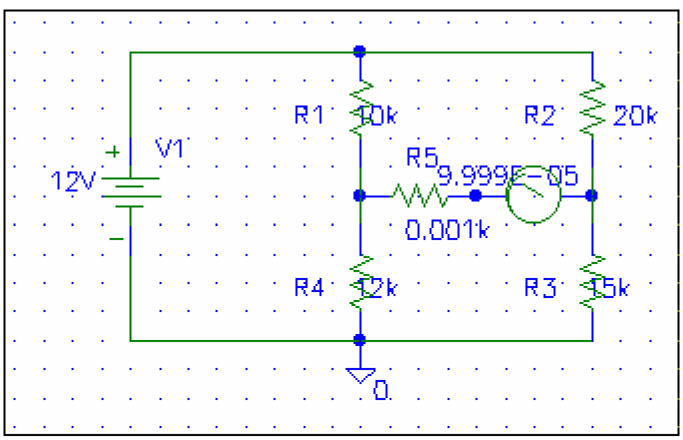



$$V_A = 30x4 = 120, \qquad V_B = \frac{20}{25}(60) = 48, \qquad V_{Th} = V_A - V_B = 72 \text{ V}$$

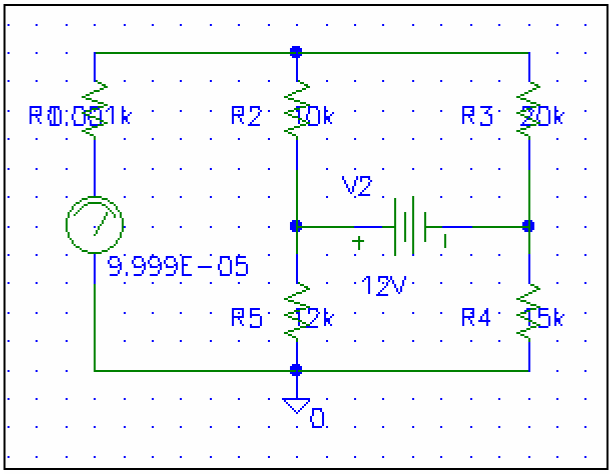
**Chapter 4, Solution 89**

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 $99.99\mu$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, 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)% = **<u>21.3%</u>**

**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>**

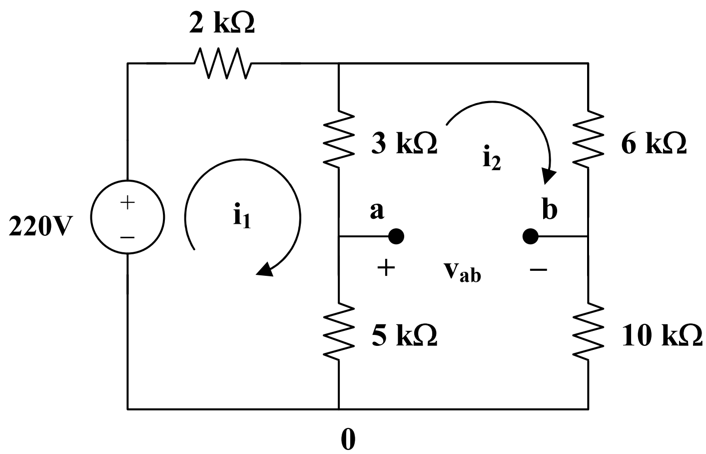
(b) For $0 < R_x < 100$ ohms

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

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

**Chapter 4, 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.




(a)

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

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

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

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

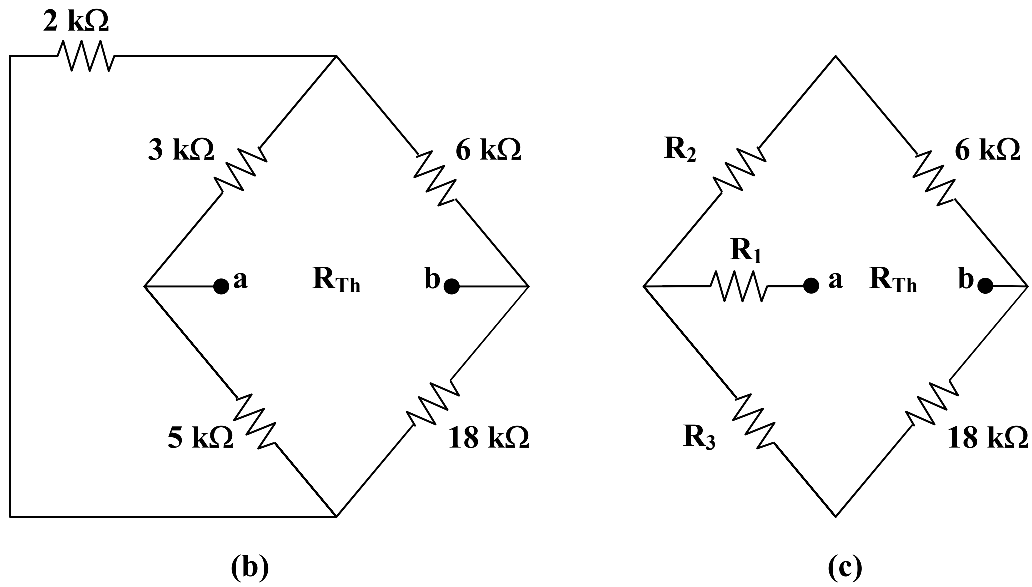
Solving (1) and (3),

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

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

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

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




(b) (c)

$R_1 = 3x5/(2 + 3 + 5) = 1.5$ k ohms, $R_2 = 2x3/10 = 600$ ohms,

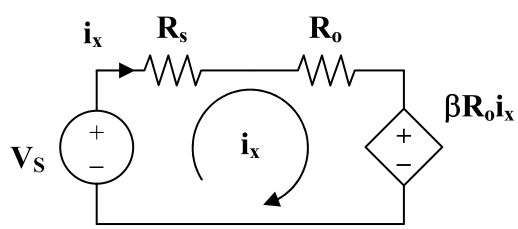
$R_3 = 2x5/10 = 1$ k ohm.

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

$R_L = R_{Th} =$ **<u>6.398 k ohms</u>**

$P_{max} = (V_{Th})^2/(4R_{Th}) = (20.625)^2/(4x6.398) =$ **<u>16.622 mWatts</u>**

**Chapter 4, Solution 93.**




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

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

**Chapter 4, Solution 94.**

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

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

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

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

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

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

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

Combining (2) and (1a) gives,

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

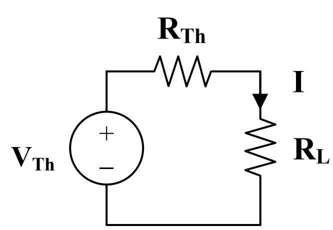
$$= (1 – 0.125)(100)/0.125 = \underline{\textbf{700 ohms}}$$

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, Solution 95.**

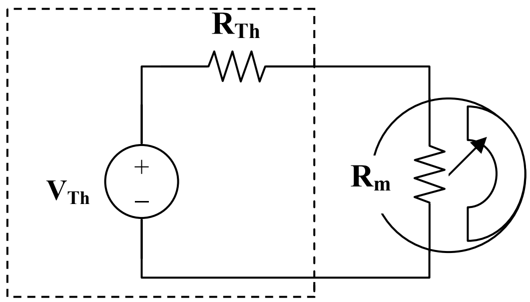
Let 1/sensitivity = 1/(20 k ohms/volt) = 50 μA

For the 0 – 10 V scale,

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

For the 0 – 50 V scale,

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




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

(a) A 4V reading corresponds to

$$I = (4/10)I_{fs} = 0.4\text{x}50\ \mu A = 20\ \mu A$$

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

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

(b) A 5V reading corresponds to

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

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

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

From (1) and (2)

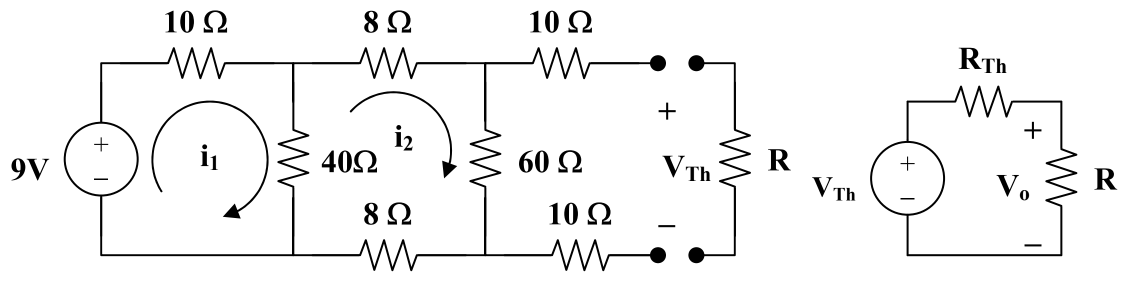
$0 = -1 + 15\ \mu A\ R_{Th}$ which leads to $R_{Th}$ = **66.67 k ohms**

From (1),

$V_{Th} = 4 + 20\text{x}10^{-6}\text{x}(1/(15\text{x}10^{-6}))$ = **5.333 V**

**Chapter 4, Solution 96.**

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




(a) (b)

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

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),

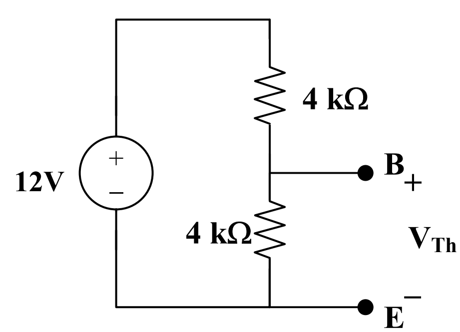
$$V_o = [R/(R + R_{Th})]V_{Th} = 1.8$$

$R/(R + 37.14) = 1.8/5.143$ 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, Solution 97.**

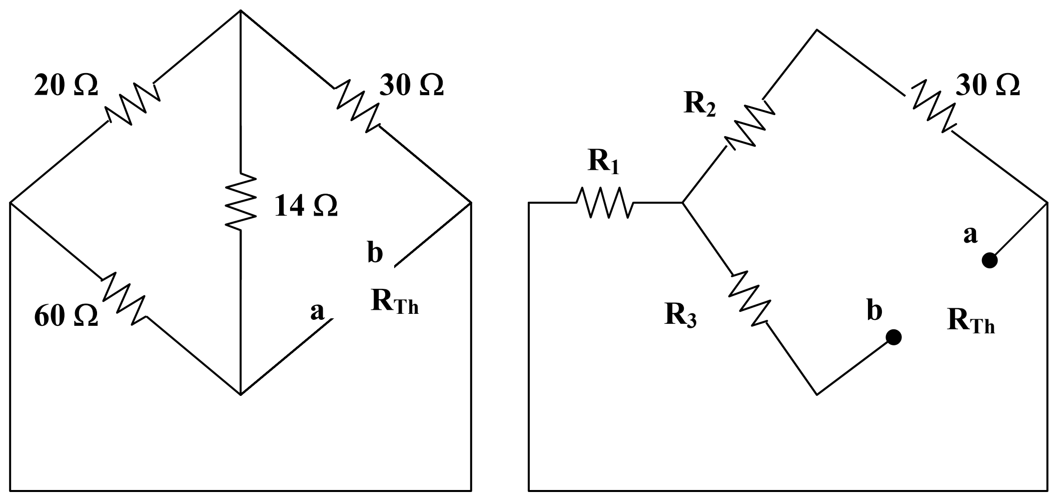


$R_{Th} = R_1||R_2 = 6||4 = $ **<u>2.4 k ohms</u>**

$V_{Th} = [R_2/(R_1 + R_2)]v_s = [4/(6 + 4)](12) = $ **<u>4.8 V</u>**

**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),




**(a)** **(b)**

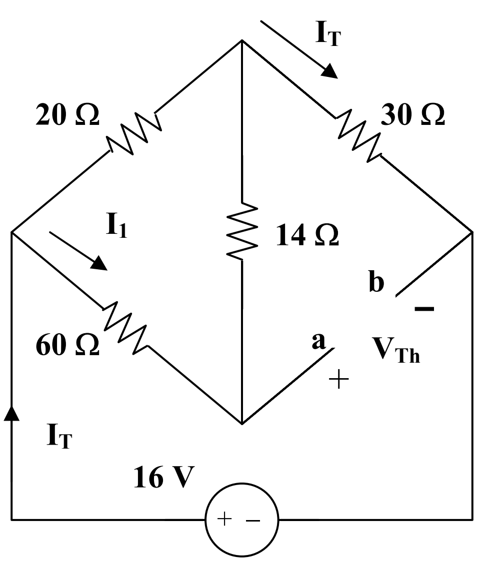
$$R_1 = 20\text{x}60/(20 + 60 + 14) = 1200/94 = 12.97 \text{ ohms}$$

$$R_2 = 20\text{x}14/94 = 2.98 \text{ ohms}$$

$$R_3 = 60\text{x}14/94 = 8.94 \text{ ohms}$$

$$R_{Th} = R_3 + R_1||(R_2 + 30) = 8.94 + 12.77||32.98 = 18.15 \text{ ohms}$$

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




**(c)**

$$I_T = 16/(30 + 15.74) = 350 \text{ mA}$$

$$I_1 = [20/(20 + 60 + 14)]I_T = 94.5 \text{ mA}$$

$$V_{Th} = 14I_1 + 30I_T = 11.824 \text{ V}$$

$$I_{40} = V_{Th}/(R_{Th} + 40) = 11.824/(18.15 + 40) = 203.3 \text{ mA}$$

$$P_{40} = I_{40}^2R = \underline{\mathbf{1.654\ watts}}$$