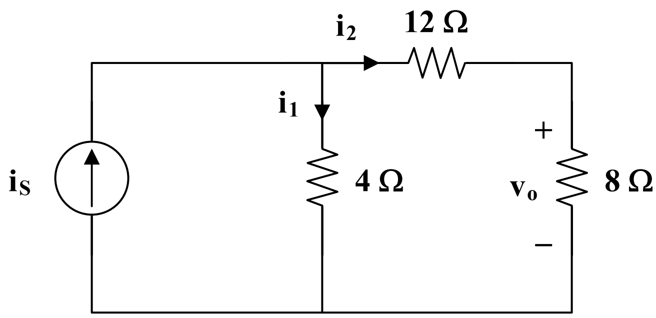
CHAPTER 4

P.P.4.1



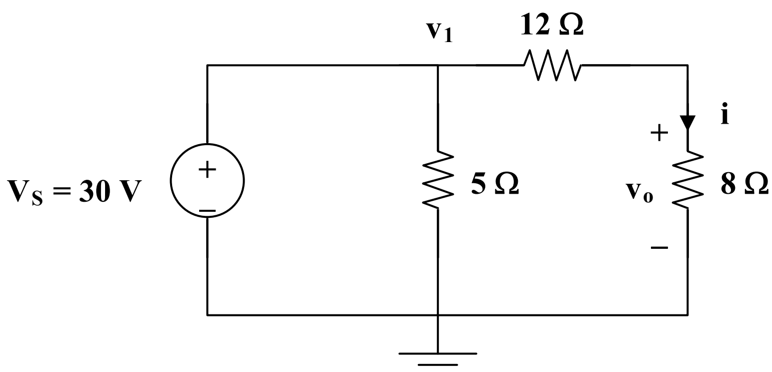
By current division, $i_2 = \frac{4}{4+12+8} i_s = \frac{1}{6} i_s$

$$v_0 = 8i_2 = \frac{4}{3} i_s$$

When i_s = 30 A, $v_0 = \frac{4}{3}(30) = \mathbf{40\ V}$

When i_s = 45 A, $v_0 = \frac{4}{3}(45) = \mathbf{60\ V}$

P.P.4.2

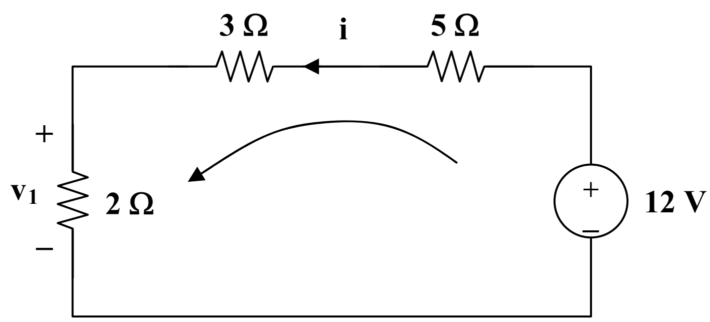


Let v_o = 1 volt. Then i = $\frac{1}{8}$ and $v_1 = \frac{1}{8}(12 + 8) = 2.5$

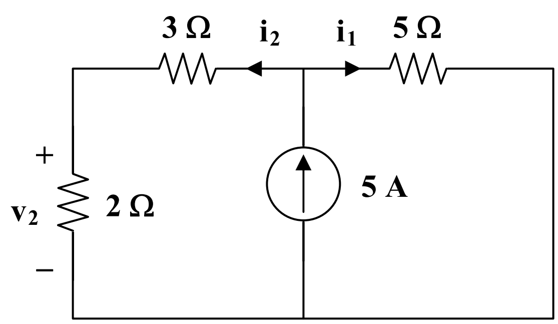
giving v_s = 2.5V.

If v_s = 40V, then v_0 = (40/2.5)(1) = **16 V**

P.P.4.3 Let $v_0 = v_1 + v_2$, where v_1 and v_2 are contributions to the 12–V and 5–A sources respectively.



(a)



(b)

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

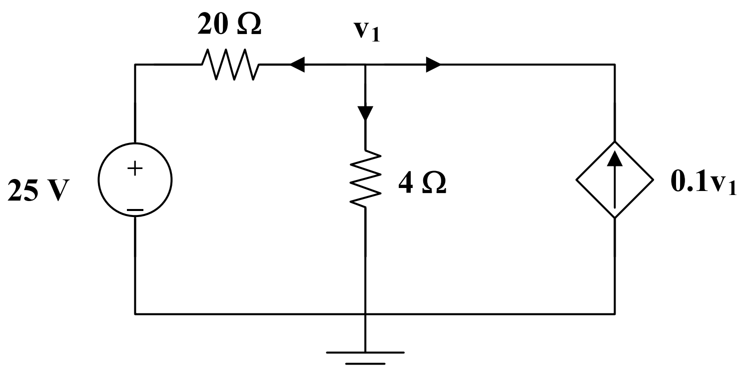
$(2 + 3 + 5)i – 12 = 0$ or $i = 12/(10) = 1.2$ A
$v_1 = 2i = 2.4$ V

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

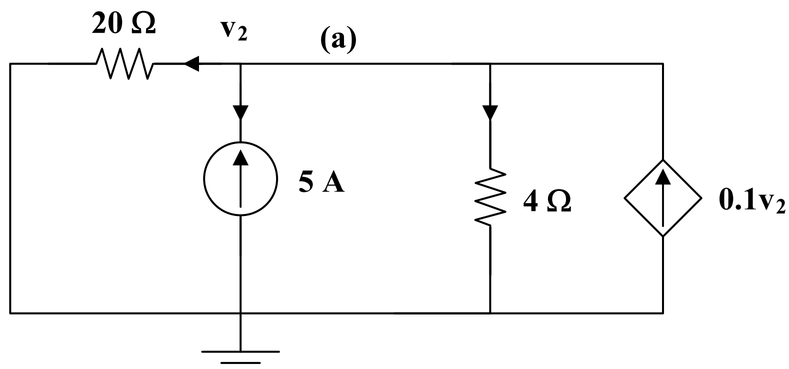
Since the resistors are equal (5 = 2 + 3) then the current divides equally and
$i_1 = i_2 = 5/2 = 2.5$ and $v_2 = 2i_2 = 5$ V

Thus,
$v = v_1 + v_2 = 2.4 + 5 = \mathbf{7.4\ V}$

P.P.4.4 Let $v_x = v_1 + v_2$, where v_1 and v_2 are due to the 25-V and 5-A sources respectively.



(a)



(b)

To obtain v_1, consider Fig. (a).

$$-0.1v_1 + \frac{v_1 - 25}{20} + \frac{v_1 - 0}{4} = 0 \quad \text{or} \quad 0.2v_1 = 25/20 = 1.25 \text{ or } v_1 = 6.25 \text{ V}$$

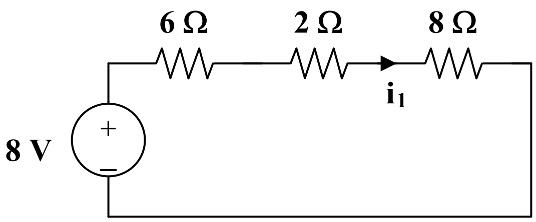
For v_2, consider Fig. (b).

$$-5 - 0.1v_2 + \frac{v_2 - 0}{20} + \frac{v_2 - 0}{4} = 0 \text{ or } 0.2v_2 = 5 \text{ or } v_2 = 25 \text{ V}$$

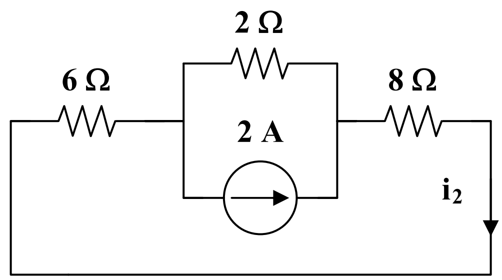
$v_x = v_1 + v_2 =$ **31.25 V**

P.P.4.5 Let $i = i_1 + i_2 + i_3$

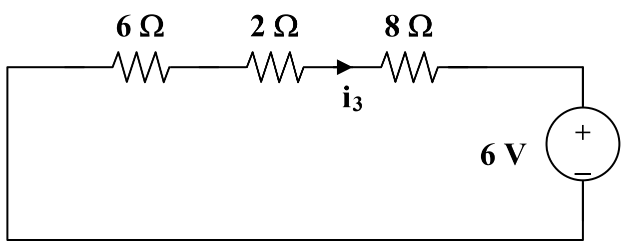
where i_1, i_2, and i_3 are contributions due to the 8-V, 2-A, and 6-V sources respectively.



(a)



(b)



(c)

For i_1, consider Fig. (a), $i_1 = \dfrac{8}{6+2+8} = 0.5\,\text{A}$

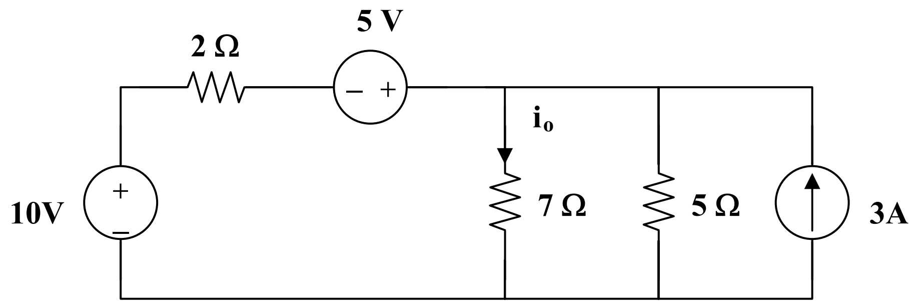
For i_2, consider Fig. (b). By current division, $i_2 = \dfrac{2}{2+14}(2) = 0.25$

For i_3, consider Fig. (c), $i_3 = \dfrac{-6}{16} = -0.375\text{A}$

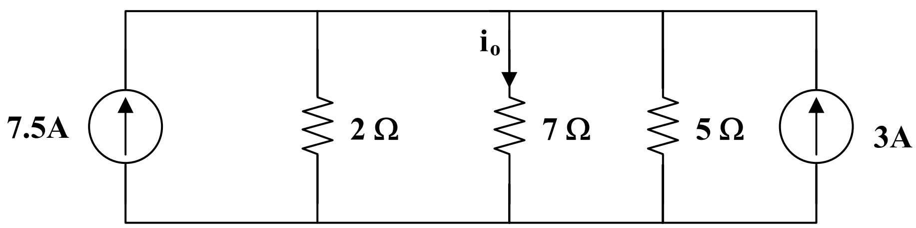
Thus, $i = i_1 + i_2 + i_3 = 0.5 + 0.25 - 0.375 =$ **375 mA**

P.P.4.6 Combining the 6-Ω and 3-Ω resistors in parallel gives $6 \| 3 = \dfrac{6\text{x}3}{9} = 2\Omega$.

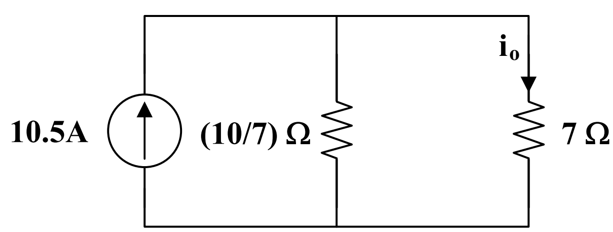
Adding the 1-Ω and 4-Ω resistors in series gives 1 + 4 = 5Ω. Transforming the left current source in parallel with the 2-Ω resistor gives the equivalent circuit as shown in Fig. (a).



(a)



(b)



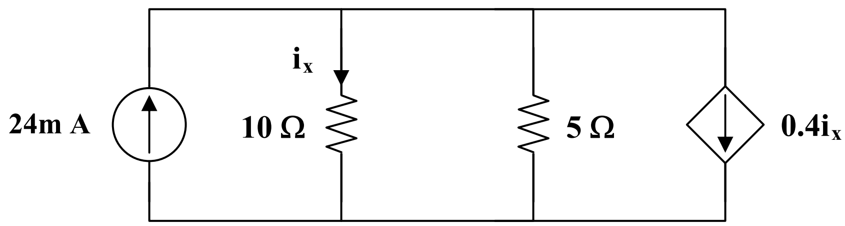
(c)

Adding the 10-V and 5-V voltage sources gives a 15-V voltage source. Transforming the 15-V voltage source in series with the 2-Ω resistor gives the equivalent circuit in Fig. (b). Combining the two current sources and the 2-Ω and 5-Ω resistors leads to the circuit in Fig. (c). Using circuit division,

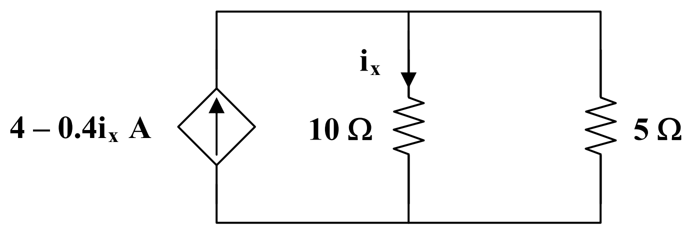
$$i_o = \frac{\frac{10}{7}}{\frac{10}{7}+7}(10.5) \quad = \mathbf{1.78\ A}$$

P.P.4.7 We transform the dependent voltage source as shown in Fig. (a). We combine the two current sources in Fig. (a) to obtain Fig. (b). By the current division principle,

$$i_x = \frac{5}{15}(0.024 - 0.4i_x) \longrightarrow i_x = \mathbf{7.059\ mA}$$

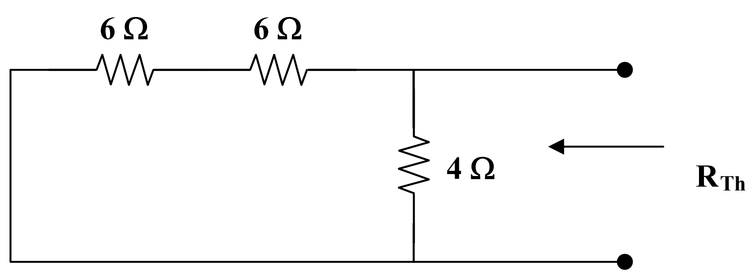


(a)

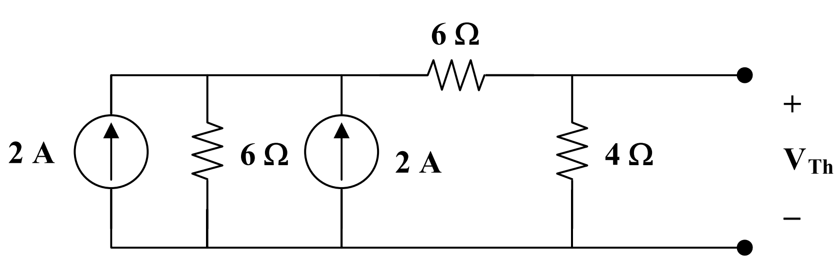


(b)

P.P.4.8 To find R_{Th}, consider the circuit in Fig. (a).



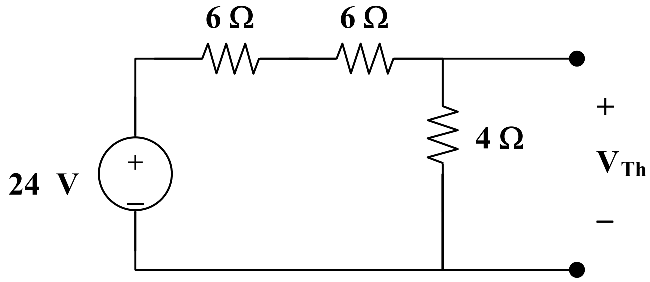
(a)



(b)

$$R_{Th} = (6+6)\|4 = \frac{12x4}{18} = \mathbf{3\Omega}$$

To find V_{Th}, we use source transformations as shown in Fig. (b) and (c).



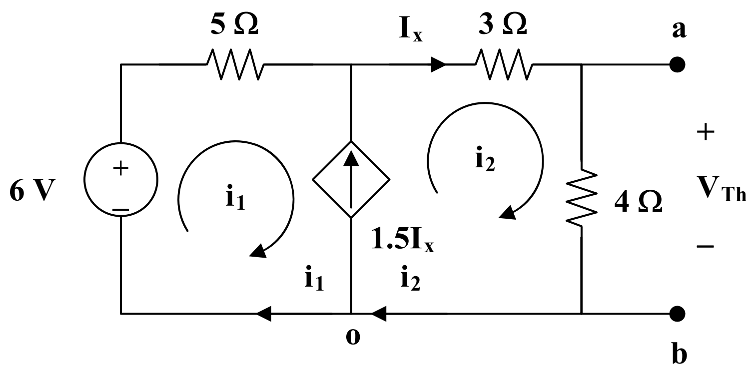
(c)

Using current division in Fig. (c),

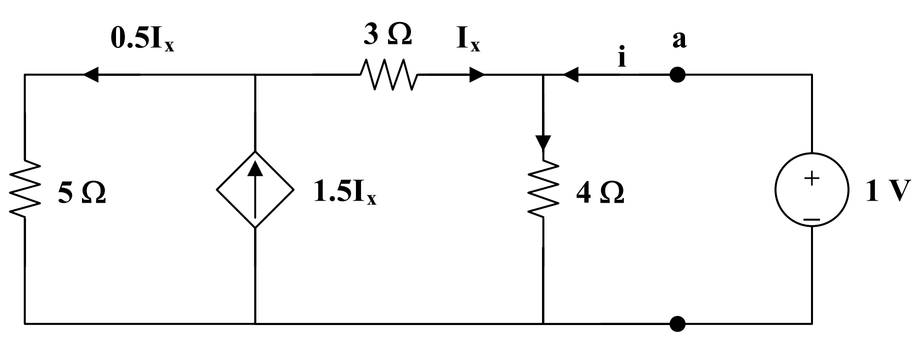
$$V_{Th} = \frac{4}{4+12}(24) = \mathbf{6\ V}$$

$$i = \frac{V_{Th}}{R_{Th}+1} = \frac{6}{3+1} = \mathbf{1.5\ A}$$

P.P.4.9 To find V_{Th}, consider the circuit in Fig. (a).



(a)



(b)

$I_x = i_2$
$i_2 - i_1 = 1.5I_x = 1.5i_2 \longrightarrow \quad i_2 = -2i_1 \qquad (1)$

For the supermesh, $-6 + 5i_1 + 7i_2 = 0 \qquad (2)$

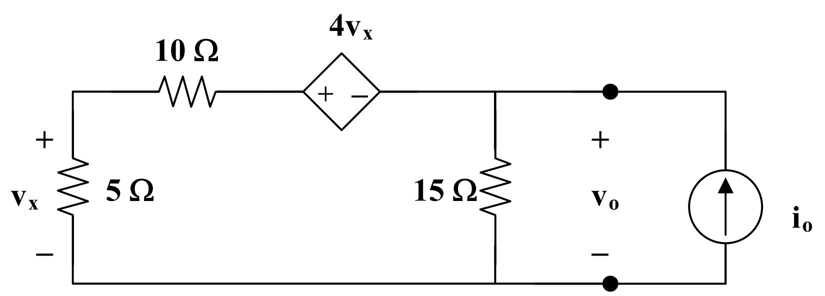
From (1) and (2), $i_2 = 4/(3)A$

$V_{Th} = 4i_2 = \mathbf{5.333V}$

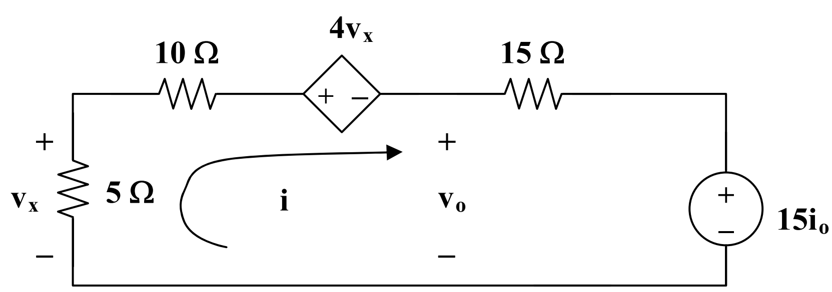
To find R_{Th}, consider the circuit in Fig. (b). Applying KVL around the outer loop,

$$5(0.5I_x) - 1 - 3I_x = 0 \quad \longrightarrow \quad I_x = -2$$
$$i = \frac{1}{4} - I_x = 2.25$$
$$R_{Th} = \frac{1}{i} = \frac{1}{2.25} = \mathbf{444.4\ m\Omega}$$

P.P.4.10 Since there are no independent sources, $V_{Th} = \mathbf{0}$



(a)

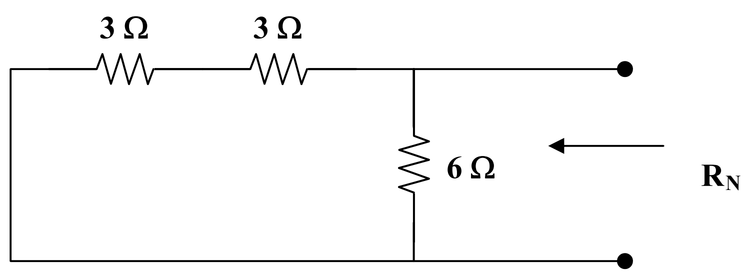


(b)

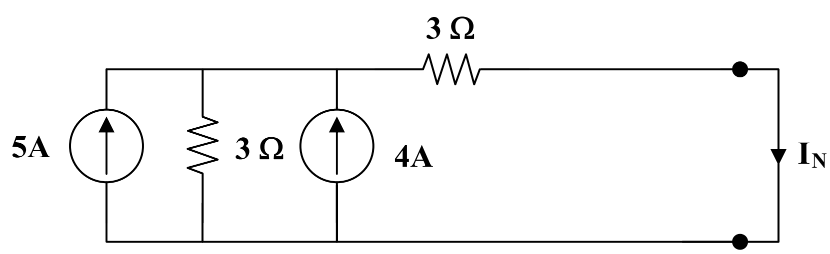
To find R_{Th}, consider Fig.(a). Using source transformation, the circuit is transformed to that in Fig. (b). Applying KVL,).

But v_x = -5i. Hence, 30i - 20i + 15i_o = 0 $\longrightarrow$ 10i = -15i_o
v_o = (15i + 15i_o) = 15(-1.5i_o + i_o) = -7.5i_o
R_{Th} = v_o/(i_o) = **–7.5Ω It needs to be noted that this negative resistance indicates we must have an active source (a dependent source).**

P.P.4.11



(a)

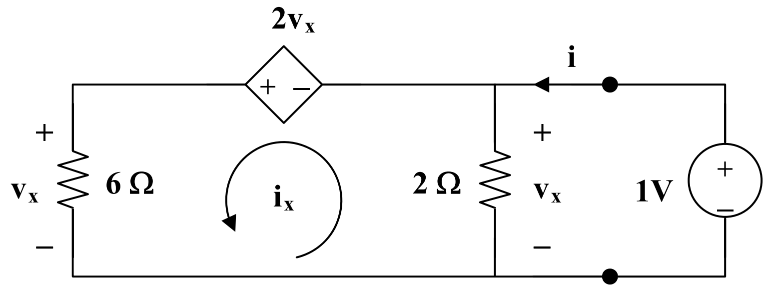


(b)

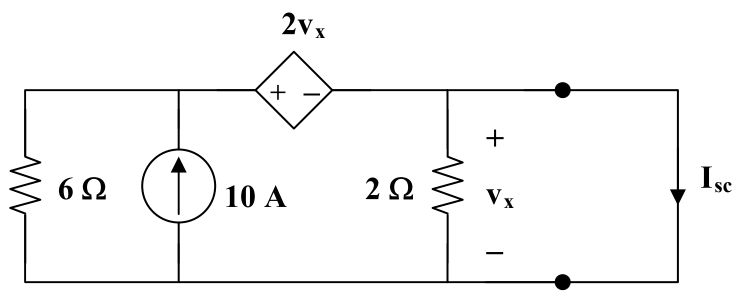
From Fig. (a), $R_N = (3+3)\|6 =$ **3 Ω**

From Fig. (b), $I_N = \frac{1}{2}(5+4) =$ **4.5A**

P.P.4.12



(a)



(b)

To get R_N consider the circuit in Fig. (a). Applying KVL, $6i_x - 2v_x - 1 = 0$

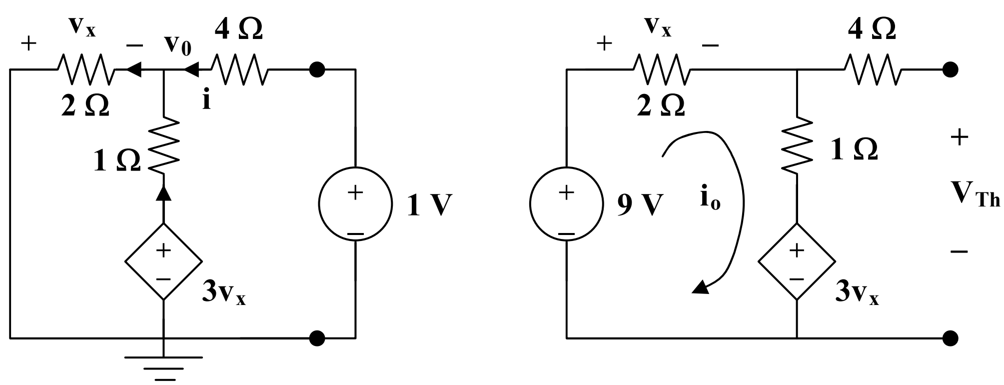
But $v_x = 1$, $6i_x = 3 \longrightarrow$ $i_x = 0.5$

$$i = i_x + \frac{v_x}{2} = 0.5 + 0.5 = 1$$

$$R_N = R_{Th} = \frac{1}{i} = \mathbf{1\Omega}$$

To find I_N, consider the circuit in Fig. (b). Because the 2Ω resistor is shorted, $v_x = 0$ and the dependent source is inactive. Hence, $I_N = i_{sc} =$ **10A**.

P.P.4.13 We first need to find R_{Th} and V_{Th}. To find R_{Th}, we consider the circuit in Fig. (a).



(a) (b)

Applying KCL at the top node gives

$$\frac{1-v_o}{4}+\frac{3v_x-v_o}{1}=\frac{v_o}{2}$$

But $v_x = -v_o$. Hence

$$\frac{1-v_o}{4}-4v_o=\frac{v_o}{2} \longrightarrow v_o = 1/(19)$$

$$i=\frac{1-v_o}{4}=\frac{1-\frac{1}{19}}{4}=\frac{9}{38}$$

$R_{Th} = 1/i = 38/(9) = 4.222\Omega$

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

$$-9 + 2i_o + i_o + 3v_x = 0$$

But $v_x = 2i_o$. Hence,

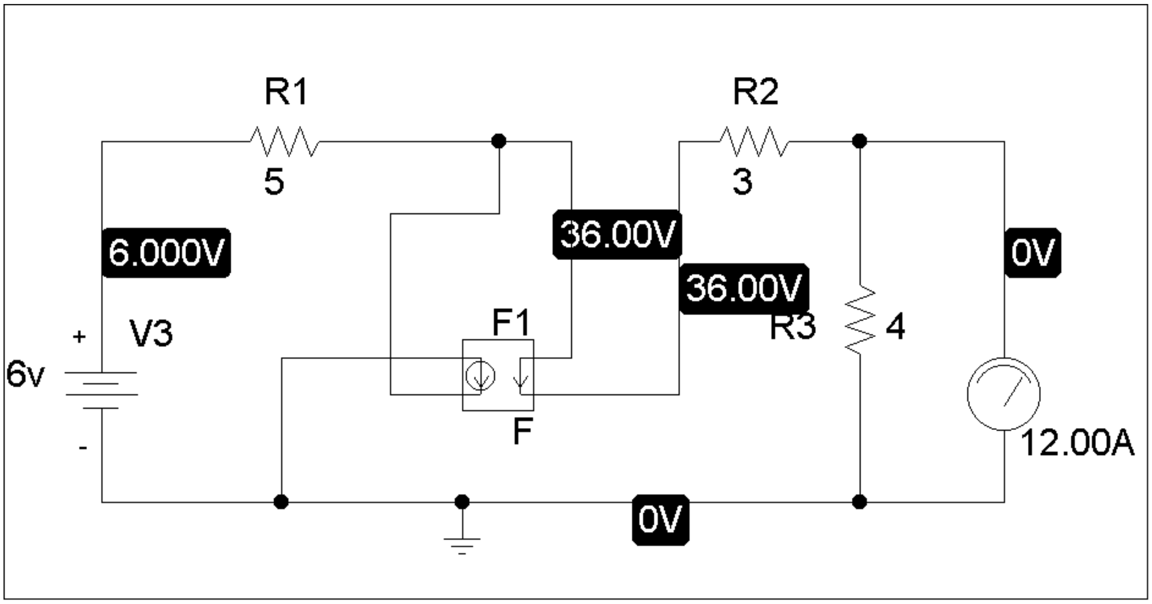
$$9 = 3i_o + 6i_o = 9i_o \longrightarrow i_o = 1A$$

$$V_{Th} = 9 - 2i_o = 7V$$

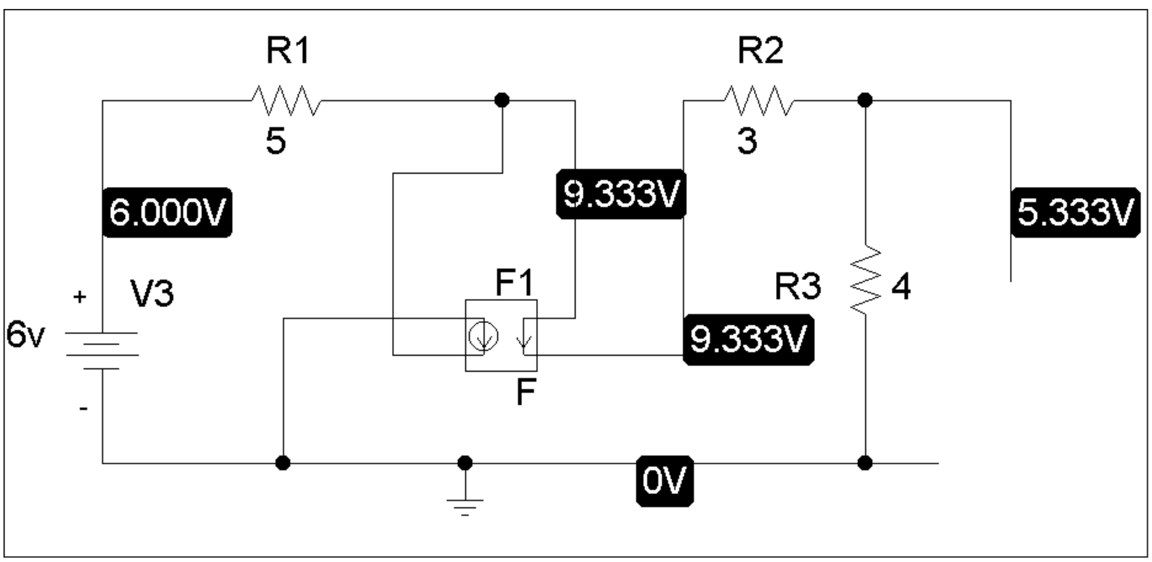
$R_L = R_{Th} =$ **4.222 Ω**

$$P_{max} = \frac{v_{Th}^2}{4R_L}=\frac{49}{4(4.222)}= \mathbf{2.901\ W}$$

P.P.4.14 We will use PSpice to find V_{oc} and I_{sc} which then can be used to find V_{Th} and R_{th}.

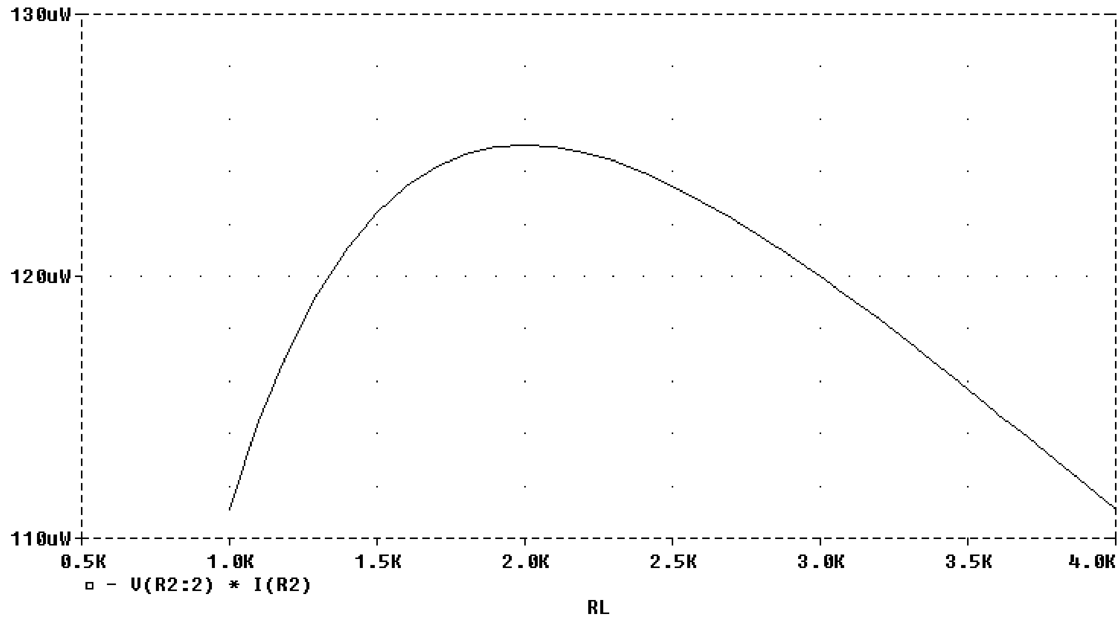


Clearly I_{sc} = 12 A

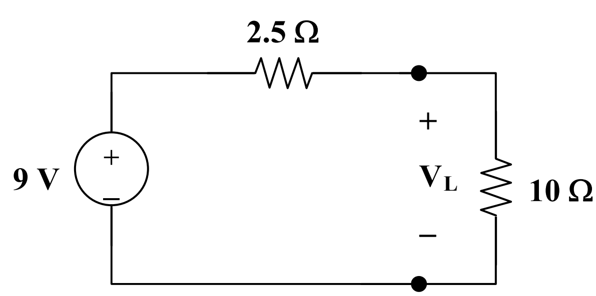


Clearly V_{Th} = I_{oc} = **5.333 volts**. R_{Th} = Voc/Isc = 5.333/12 = **444.4 mΩ**.

P.P.4.15 The schematic is the same as that in Fig. 4.56 except that the 1-kΩ resistor is replaced by 2-kΩ resistor. The plot of the power absorbed by R_L is shown in the figure below. From the plot, it is clear that the maximum power occurs when $R_L = 2k\Omega$ and it is **125 μW**.



P.P.4.16 $V_{Th} = 9V,\ R_{Th} = (v_{oc} - V_L)\dfrac{R_L}{V_L} = (9-1)\dfrac{20}{8} = 2.5\Omega$



$$V_L = \frac{10}{10+2.5}(9) = \mathbf{7.2\ V}$$

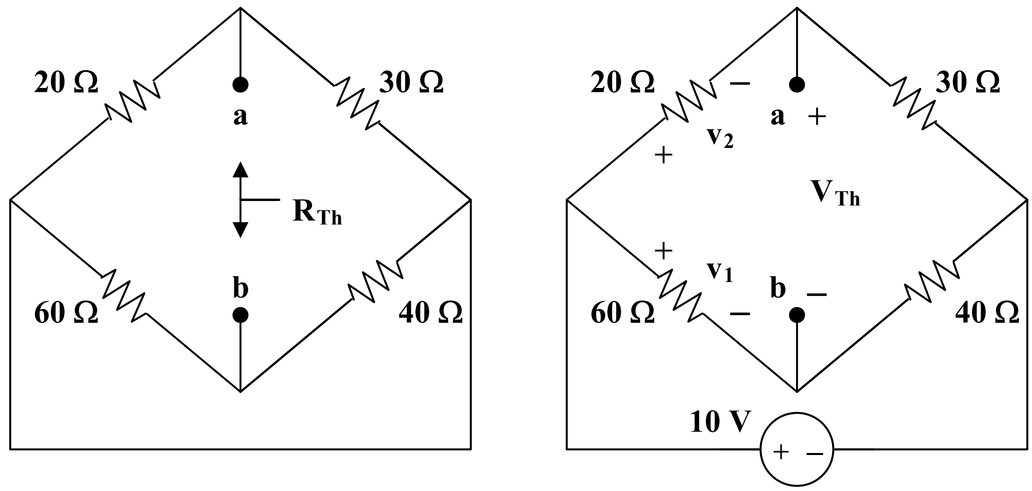
P.P.4.17 $R_1 = R_3 = 1\text{k}\Omega$, $R_2 = 3.2\text{k}\Omega$

$$R_x = \frac{R_3}{R_1} R_2 = R_2 = \mathbf{3.2\ k\Omega}$$

P.P.4.18 We first find R_{Th} and V_{Th}. To get R_{Th}, consider the circuit in Fig. (a).

$$R_{Th} = 20 \| 30 + 60 \| 40 = \frac{20x30}{50} + \frac{60x40}{100}$$

$$= 12 + 24 = 36\Omega$$



(a) **(b)**

To find V_{Th}, we use Fig. (b). Using voltage division,

$$v_1 = \frac{60}{100}(16) = 9.6, \quad v_2 = \frac{20}{50}(16) = 6.4$$

But $-v_1 + v_2 + v_{Th} = 0 \longrightarrow v_{Th} = v_1 - v_2 = 9.6 - 6.4 = 32V$

$$I_G = \frac{V_{Th}}{R_{Th} + R_m} = \frac{3.2}{3.6 + 1.4} = \mathbf{64mA}$$