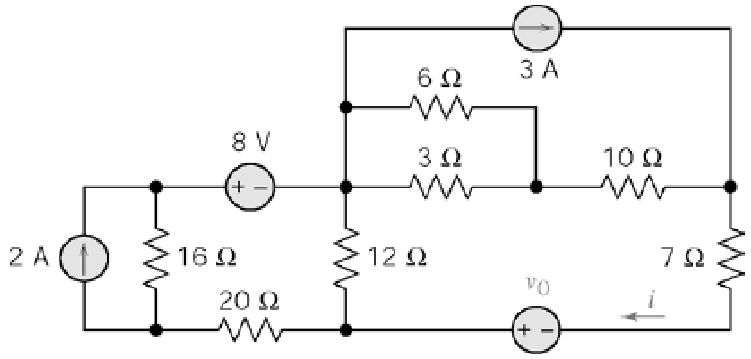
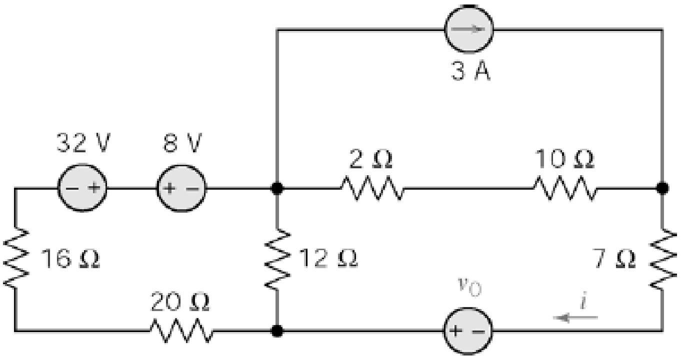
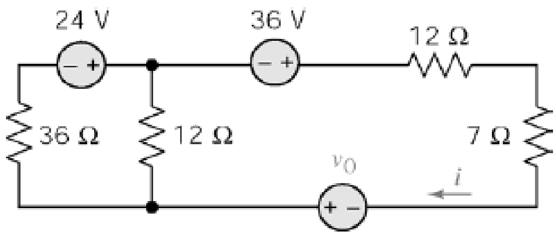
P5.3-3



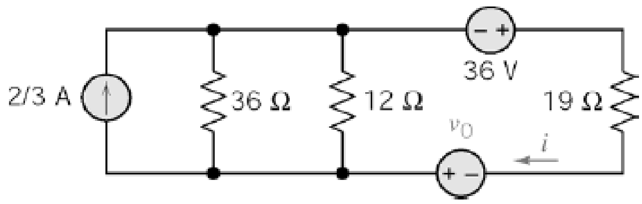
Source transformation at left; equivalent resistor for parallel 6 and 3 Ω resistors:



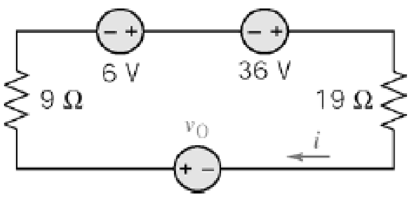
Equivalents for series resistors, series voltage source at left; series resistors, then source transformation at top:



Source transformation at left; series resistors at right:



Parallel resistors, then source transformation at left:



Finally, apply KVL to loop

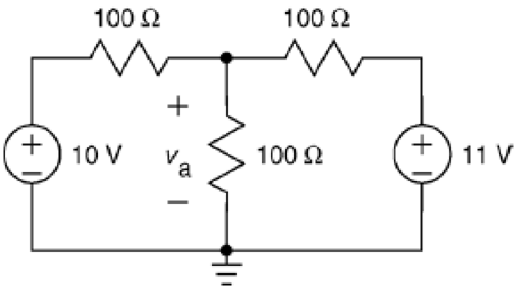
$$-6 + i\,(9+19) - 36 - v_o = 0$$

$$i = 5/2 \;\Rightarrow v_o = -42 + 28\,(5/2) = 28\text{ V}$$

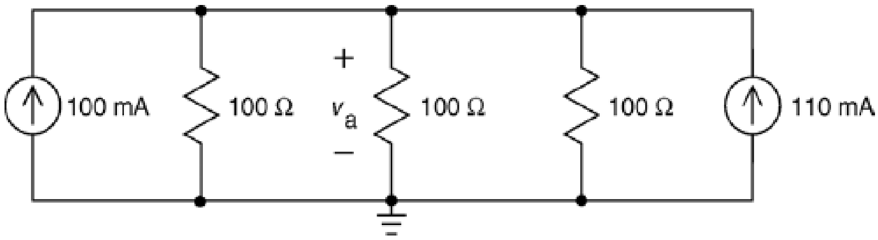
(checked using LNAP 8/15/02)

P5.3-6

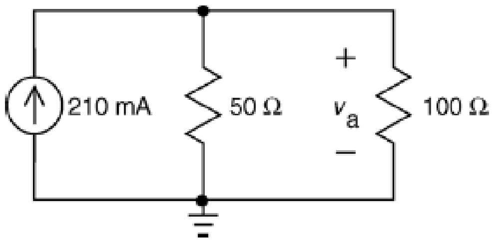
A source transformation on the right side of the circuit, followed by replacing series resistors with an equivalent resistor:



Source transformations on both the right side and the left side of the circuit:



Replacing parallel resistors with an equivalent resistor and also replacing parallel current sources with an equivalent current source:

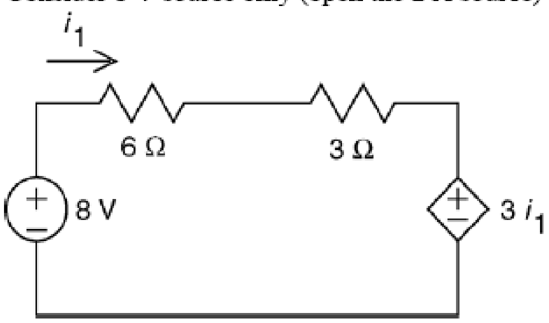


Finally,
$$v_a = \frac{50(100)}{50+100}(0.21) = \frac{100}{3}(0.21) = 7\text{ V}$$

(checked using LNAP 8/15/02)

P5.4-5

Consider 8 V source only (open the 2 A source)



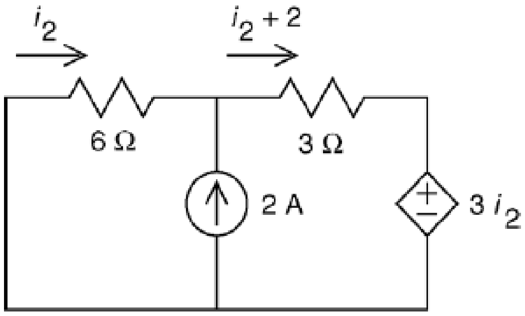
Let i_1 be the part of i_x due to the 8 V voltage source.

Apply KVL to the supermesh:

$$6\left(i_1\right)+3\left(i_1\right)+3\left(i_1\right)-8=0$$

$$i_1=\frac{8}{12}=\frac{2}{3}\text{ A}$$

Consider 2 A source only (short the 8 V source)



Let i_2 be the part of i_x due to the 2 A current source.

Apply KVL to the supermesh:

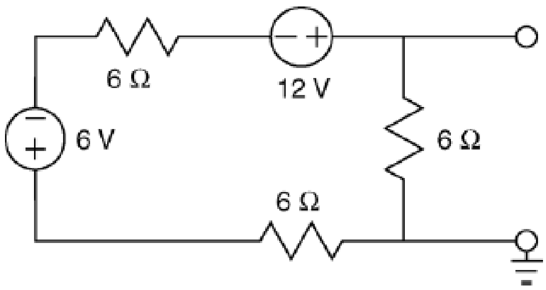
$$6\left(i_2\right)+3\left(i_2+2\right)+3\,i_2=0$$

$$i_2=\frac{-6}{12}=-\frac{1}{2}\text{ A}$$

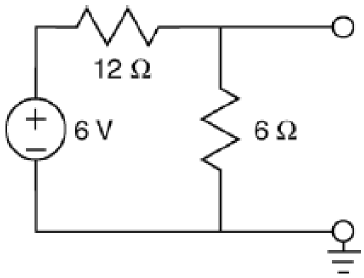
Finally, $\quad i_x=i_1+i_2=\frac{2}{3}-\frac{1}{2}=\frac{1}{6}\text{ A}$

P5.5-3

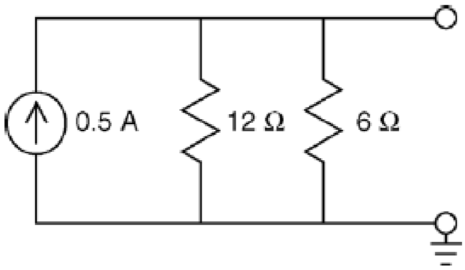
The circuit from Figure P5.5-3*a* can be reduced to its Thevenin equivalent circuit in five steps:



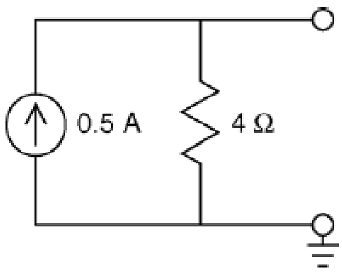
(*a*)



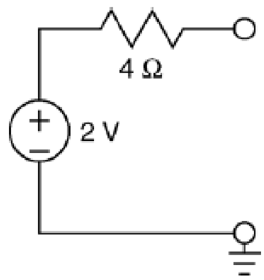
(*b*)



(*c*)



(*d*)

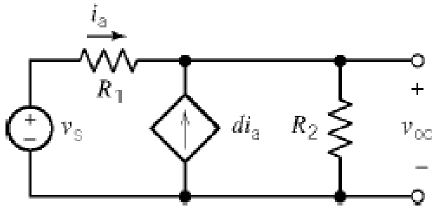


(*e*)

Comparing (*e*) to Figure P5.5-3*b* shows that the Thevenin resistance is $R_t = 4\ \Omega$ and the open circuit voltage, $v_{oc} = 2$ V.

P5.5-7

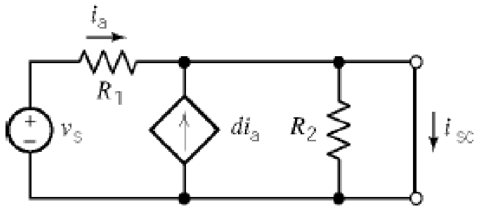
(a)



$$-v_s + R_1\, i_a + (d+1) R_2\, i_a = 0$$

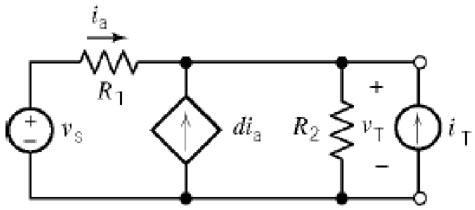
$$i_a = \frac{v_s}{R_1 + (d+1) R_2}$$

$$v_{oc} = \frac{(d+1) R_2 v_s}{R_1 + (d+1) R_2}$$



$$i_a = \frac{v_s}{R_1}$$

$$i_{sc} = (d+1)\, i_a = \frac{(d+1) v_s}{R_1}$$



$$-i_a - d\, i_a + \frac{v_T}{R_2} - i_T = 0$$

$$R_1\, i_a = -v_T$$

$$i_T = (d+1)\frac{v_T}{R_1} + \frac{v_T}{R_2} = \frac{R_2 (d+1) + R_1}{R_1 R_2} \times v_T$$

$$R_t = \frac{v_T}{i_T} = \frac{R_1 R_2}{R_1 + (d+1) R_2}$$

(b) Let $R_1 = R_2 = 1$ kΩ. Then

$$625\,\Omega = R_t = \frac{1000}{d+2} \quad\Rightarrow\quad d = \frac{1000}{625} - 2 = -0.4 \text{ A/A}$$

and

$$5 = v_{oc} = \frac{(d+1) v_s}{d+2} \quad\Rightarrow\quad v_s = \frac{-0.4+2}{-0.4+1} 5 = 13.33 \text{ V}$$

(checked using LNAP 8/15/02)

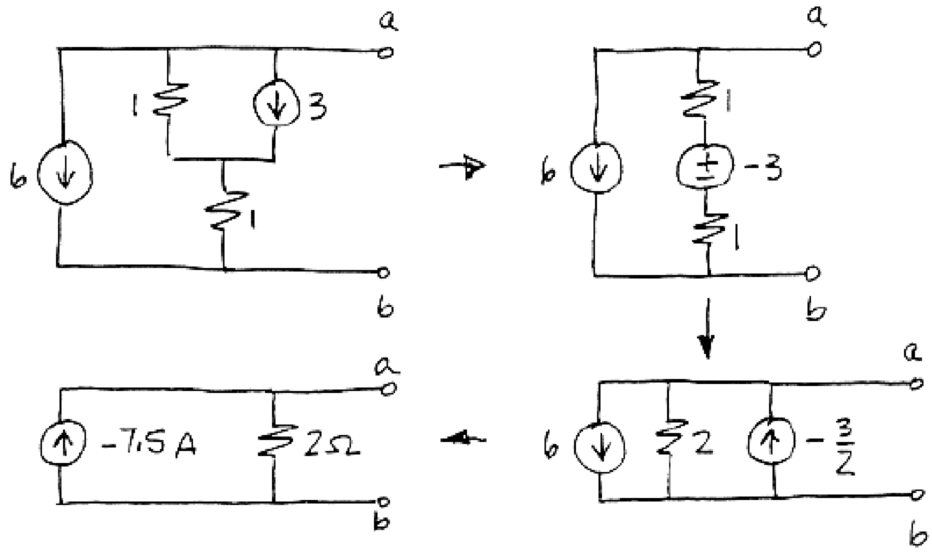
P5.5-10

The current at the point on the plot where $v = 0$ is the short circuit current, so $i_{sc} = 20$ mA.
The voltage at the point on the plot where $i = 0$ is the open circuit voltage, so $v_{oc} = -3$ V.

The slope of the plot is equal to the negative reciprocal of the Thevenin resistance, so

$$-\frac{1}{R_t} = \frac{0 - 0.002}{-3 - 0} \quad\Rightarrow\quad R_t = -150\,\Omega$$

P5.6-2



P5.6-5

To determine the value of the short circuit current, I_{sc}, we connect a short circuit across the terminals of the circuit and then calculate the value of the current in that short circuit. Figure (a) shows the circuit from Figure 4.6-5a after adding the short circuit and labeling the short circuit current. Also, the nodes have been identified and labeled in anticipation of writing node equations. Let v_1, v_2 and v_3 denote the node voltages at nodes 1, 2 and 3, respectively.

In Figure (a), node voltage v_1 is equal to the negative of the voltage source voltage. Consequently, $v_1 = -24$ V. The voltage at node 3 is equal to the voltage across a short, $v_3 = 0$. The controlling voltage of the VCCS, v_a, is equal to the node voltage at node 2, i.e. $v_a = v_2$. The voltage at node 3 is equal to the voltage across a short, i.e. $v_3 = 0$.

Apply KCL at node 2 to get

$$\frac{v_1 - v_2}{3} = \frac{v_2 - v_3}{6} \Rightarrow 2\,v_1 + v_3 = 3\,v_2 \Rightarrow -48 = 3\,v_a \Rightarrow v_a = -16 \text{ V}$$

Apply KCL at node 3 to get

$$\frac{v_2 - v_3}{6} + \frac{4}{3}v_2 = i_{sc} \Rightarrow \frac{9}{6}v_a = i_{sc} \Rightarrow i_{sc} = \frac{9}{6}(-16) = -24 \text{ A}$$

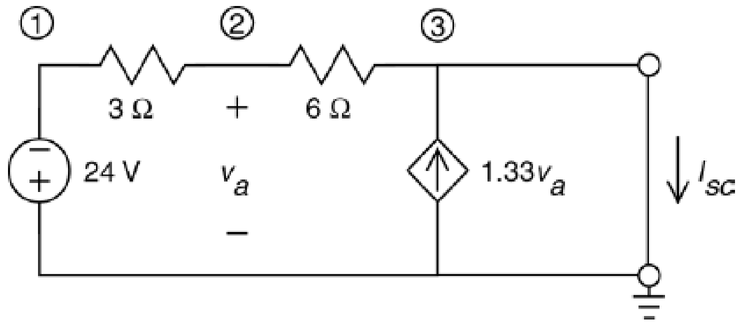


Figure (a) Calculating the short circuit current, I_{sc}, using mesh equations.

To determine the value of the Thevenin resistance, R_{th}, first replace the 24 V voltage source by a 0 V voltage source, i.e. a short circuit. Next, connect a current source circuit across the terminals of the circuit and then label the voltage across that current source as shown in Figure (b). The Thevenin resistance will be calculated from the current and voltage of the current source as

$$R_{th} = \frac{v_T}{i_T}$$

Also, the nodes have been identified and labeled in anticipation of writing node equations. Let v_1, v_2 and v_3 denote the node voltages at nodes 1, 2 and 3, respectively.

In Figure (b), node voltage v_1 is equal to the across a short circuit, i.e. $v_1 = 0$. The controlling voltage of the VCCS, v_a, is equal to the node voltage at node 2, i.e. $v_a = v_2$. The voltage at node 3 is equal to the voltage across the current source, i.e. $v_3 = v_T$.

Apply KCL at node 2 to get

$$\frac{v_1 - v_2}{3} = \frac{v_2 - v_3}{6} \quad \Rightarrow \quad 2\,v_1 + v_3 = 3\,v_2 \quad \Rightarrow \quad v_T = 3\,v_a$$

Apply KCL at node 3 to get

$$\frac{v_2 - v_3}{6} + \frac{4}{3}v_2 + i_T = 0 \quad \Rightarrow \quad 9\,v_2 - v_3 + 6\,i_T = 0$$

$$\Rightarrow \quad 9\,v_a - v_T + 6\,i_T = 0$$

$$\Rightarrow \quad 3\,v_T - v_T + 6\,i_T = 0 \quad \Rightarrow \quad 2\,v_T = -6\,i_T$$

Finally,

$$R_t = \frac{v_T}{i_T} = -3\,\Omega$$

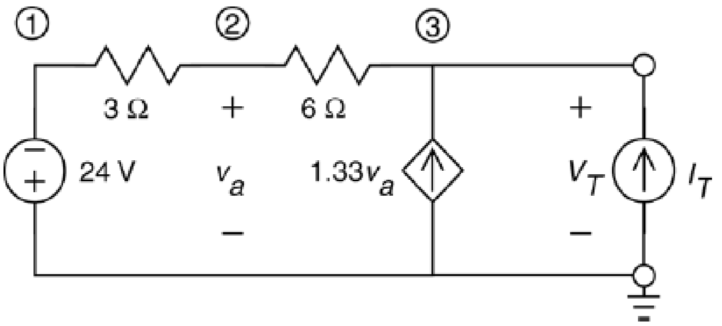


Figure (b) Calculating the Thevenin resistance, $R_{th} = \dfrac{v_T}{i_T}$, using mesh equations.

To determine the value of the open circuit voltage, v_{oc}, we connect an open circuit across the terminals of the circuit and then calculate the value of the voltage across that open circuit. Figure (c) shows the circuit from Figure P 4.6-5a after adding the open circuit and labeling the open circuit voltage. Also, the nodes have been identified and labeled in anticipation of writing node equations. Let v_1, v_2 and v_3 denote the node voltages at nodes 1, 2 and 3, respectively.

In Figure (c), node voltage v_1 is equal to the negative of the voltage source voltage. Consequently, $v_1 = -24$ V. The controlling voltage of the VCCS, v_a, is equal to the node voltage at node 2, i.e. $v_a = v_2$. The voltage at node 3 is equal to the open circuit voltage, i.e. $v_3 = v_{oc}$.

Apply KCL at node 2 to get

$$\frac{v_1 - v_2}{3} = \frac{v_2 - v_3}{6} \quad \Rightarrow \quad 2\, v_1 + v_3 = 3\, v_2 \quad \Rightarrow \quad -48 + v_{oc} = 3\, v_a$$

Apply KCL at node 3 to get

$$\frac{v_2 - v_3}{6} + \frac{4}{3} v_2 = 0 \quad \Rightarrow \quad 9\, v_2 - v_3 = 0 \quad \Rightarrow \quad 9\, v_a = v_{oc}$$

Combining these equations gives

$$3\left(-48 + v_{oc}\right) = 9\, v_a = v_{oc} \quad \Rightarrow \quad v_{oc} = 72 \text{ V}$$

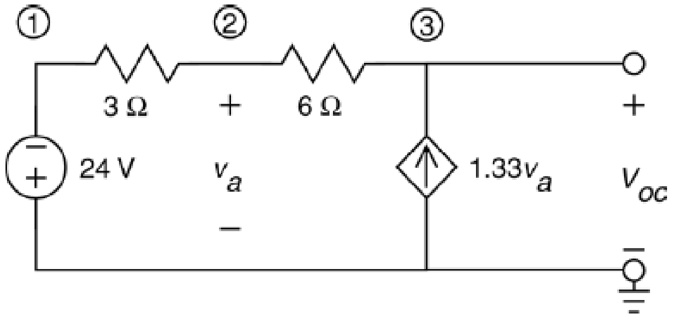
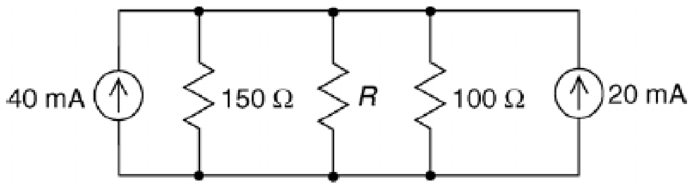


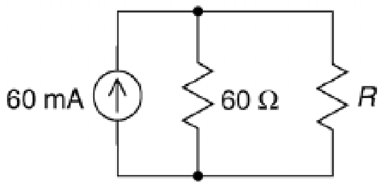
Figure (c) Calculating the open circuit voltage, v_{oc}, using node equations.

As a check, notice that

$$R_{th}\, I_{sc} = (-3)(-24) = 72 = V_{oc}$$

P5.7-2
Reduce the circuit using source transformations:

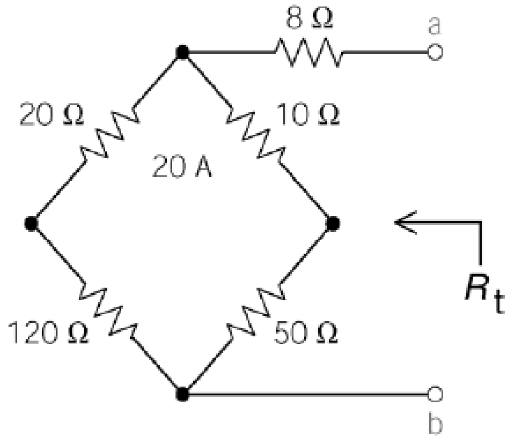


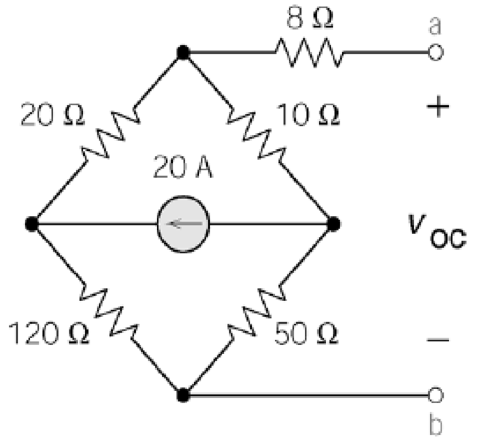


Then (a) maximum power will be dissipated in resistor R when: $R = R_t = 60\ \Omega$ and (b) the value of that maximum power is

$$P_{\max} = i_R^2(R) = (0.03)^2(60) = \underline{54 \text{ mW}}$$

P5.7-5





The required value of R is

$$R = R_t = 8 + \frac{(20+120)(10+50)}{(20+120)+(10+50)} = 50\ \Omega$$

$$v_{oc} = \left[\frac{170}{170+30}(20)\right]10 - \left[\frac{30}{170+30}(20)\right]50$$
$$= \frac{170(20)(10) - 30(20)(50)}{200} = \frac{4000}{200} = 20\ \text{V}$$

The maximum power is given by

$$p_{max} = \frac{v_{oc}^{\ 2}}{4\,R_t} = \frac{20^2}{4(50)} = 2\ \text{W}$$

DP5-1

The equation of representing the straight line in Figure DP 5-1b is $v = -R_t\, i + v_{oc}$. That is, the slope of the line is equal to -1 times the Thevenin resistance and the "v - intercept" is equal to the open circuit voltage. Therefore: $R_t = -\frac{0-5}{0.008-0} = 625\ \Omega$ and $v_{oc} = 5$ V.

Try $R_1 = R_2 = 1\,\text{k}\Omega$. ($R_1 \,||\, R_2$ must be smaller than $R_t = 625\ \Omega$.) Then

$$5 = \frac{R_2}{R_1+R_2} v_s = \frac{1}{2} v_s \quad \Rightarrow v_s = 10\ \text{V}$$

and

$$625 = R_3 + \frac{R_1 R_2}{R_1+R_2} = R_3 + 500 \quad \Rightarrow \quad R_3 = 125\ \Omega$$

Now v_s, R_1, R_2 and R_3 have all been specified so the design is complete.

DP5-3

The slope of the graph is positive so the Thevenin resistance is negative. This would require $R_3 + \frac{R_1 R_2}{R_1+R_2} < 0$, which is not possible since R_1, R_2 and R_3 will all be non-negative.

Is it not possible to specify values of v_s, R_1, R_2 and R_3 that cause the current i and the voltage v in Figure DP 5-3a to satisfy the relationship described by the graph in Figure DP 5-3b.