Ex:

$R_1 = 1\ k\Omega$ $R_3 = 1.5\ k\Omega$ ──o a

$v_s = $ (+−) 12 V $R_2 = $ 3 kΩ $i_s = $ 2 mA (↑)
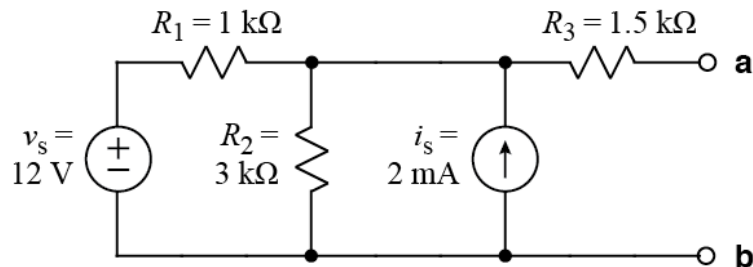
──o b

Find the Thevenin equivalent circuit at terminals a-b.

SOL'N:

V_{Th} equals the voltage across the a, b terminals when nothing is connected from a to b.

Since no current flows in R_3 when we have nothing connected from a to b, there is no voltage drop across R_3. Thus, V_{Th} equals the voltage at the node above R_2 and i_s. We could put a reference on the bottom of the circuit and label the top center node as v_{Th}, and we could use the node-v method to find V_{Th}:

$$\frac{V_{Th} - V_s}{R_1} + \frac{V_{Th}}{R_2} - i_s = 0\ A$$

or

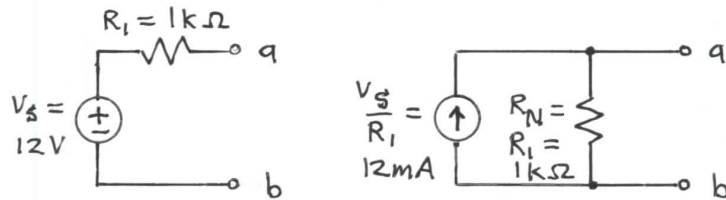$$V_{Th}\left(\frac{1}{R_1} + \frac{1}{R_2}\right) = \frac{V_s}{R_1} + i_s$$

Multiplying both sides by $R_1 R_2$ gives
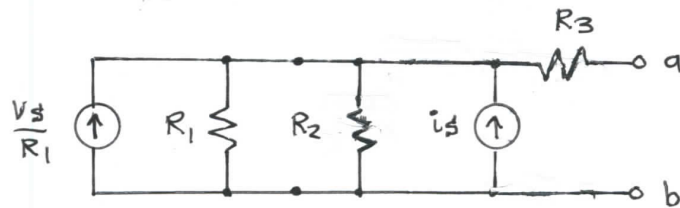
$$V_{Th}(R_2 + R_1) = V_s R_2 + i_s R_1 R_2$$

or

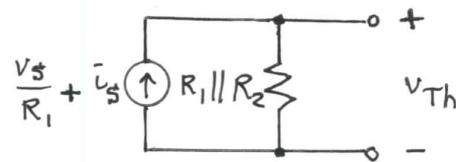$$V_{Th} = \frac{V_s R_2 + i_s R_1 R_2}{R_1 + R_2} = \frac{36k + 6k}{4k}\ V = 10.5V$$

Another way to find V_{Th} is to use source transformations. V_S and R_1 on the left side are a Thevenin equivalent that we may transform into a Norton equivalent.

Our circuit now becomes the following:

Now we may combine current sources, and R_1 with R_2. Once again, we may ignore R_3.
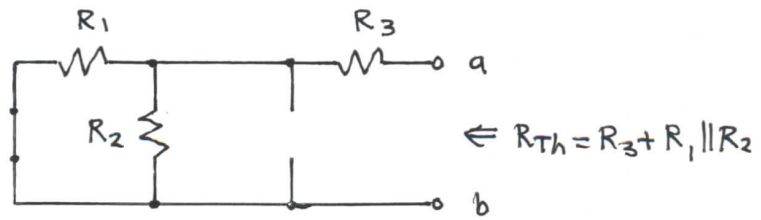

By Ohm's law, $V_{Th} = \left(\dfrac{V_S}{R_1} + i_S \right) R_1 \| R_2$

or $V_{Th} = \left(\dfrac{12V}{1k\Omega} + 2\,mA \right) \left(1k\Omega \| 3k\Omega \right) = 14mA \cdot \dfrac{3}{4} k\Omega$

or $V_{Th} = 10.5\,V$

To find R_{Th}, we turn off the independent sources and look in from the a,b terminals.

$R_{Th} = R_3 + R_1 \| R_2$ (see diagram, below)

$$R_1 \qquad R_3$$

$$\Leftarrow R_{Th} = R_3 + R_1 \| R_2$$

Note: The voltage source becomes a wire when turned off, and the current source becomes an open when turned off. That is, $0V$ = wire, $0A$ = open.