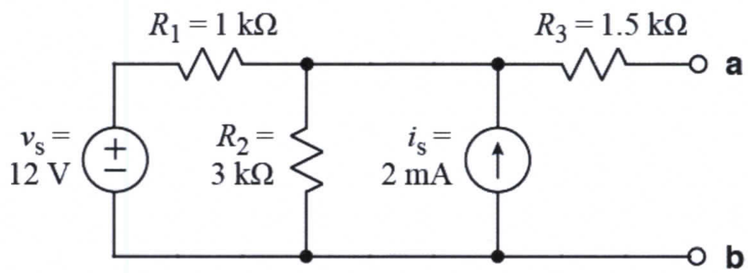
HOMEWORK #6 prob 1 solution

Ex:



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

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

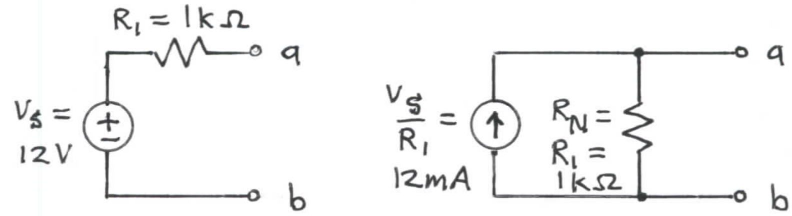
Multiplying both sides by $R_1 R_2$ gives

$$v_{Th}(R_2 + R_1) = v_s R_2 + i_s R_1 R_2$$

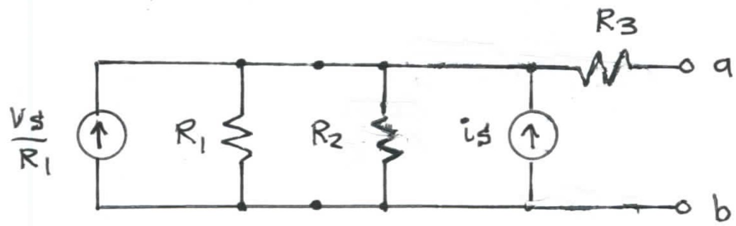
or

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

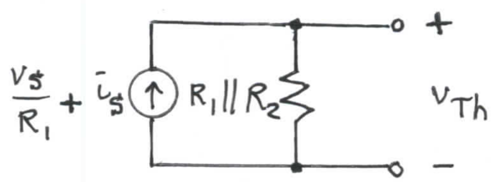
Another way to find v_{Th} is to use source transformations. v_s and R_1 on the left side are a Thevenin equivalent that we may transform into a Norton equivalent.



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.



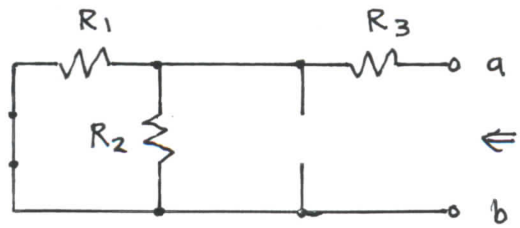
By Ohm's law, $v_{Th} = \left(\frac{v_s}{R_1} + i_s\right) R_1 \| R_2$

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

or $v_{Th} = 10.5\ V$

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

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



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

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.