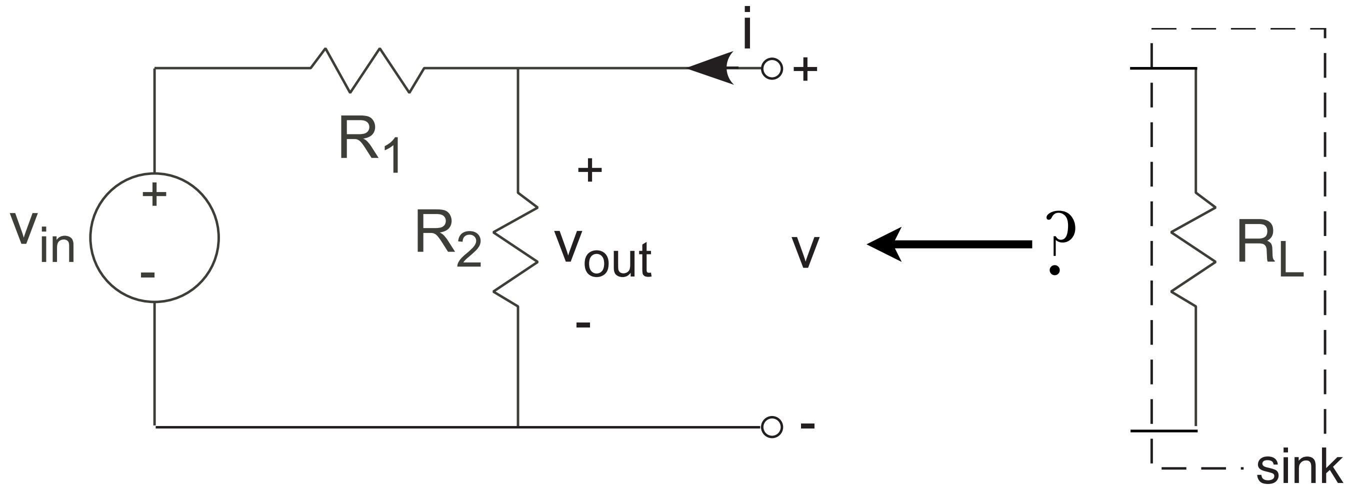
Fundamentals of Electrical Engineering

More Equivalent Circuits

- What do circuit elements "see"?
- Thévenin and Mayer-Norton equivalent circuits

RICE

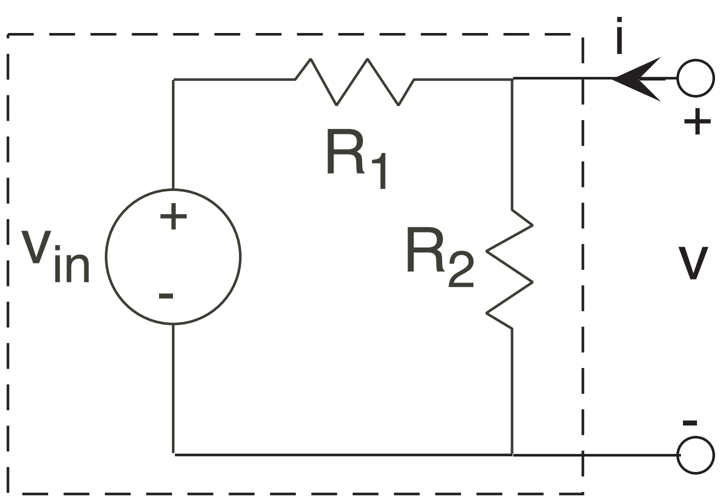
More Equivalent Circuits



Principle of Superposition

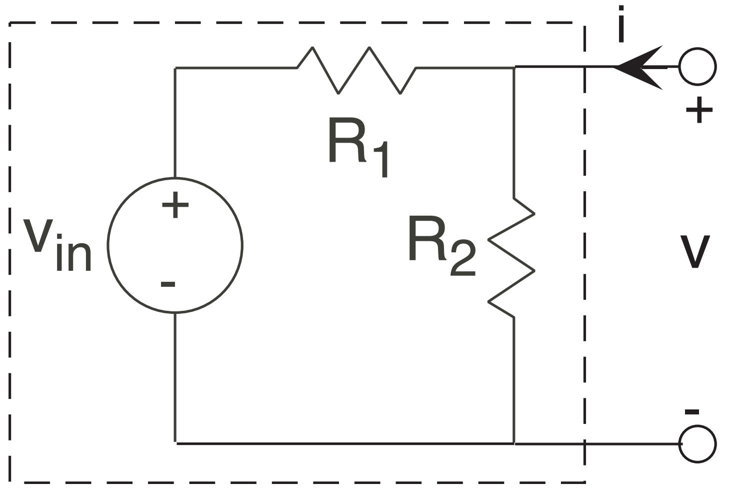
$$v = v\big|_{v_{\text{in}}=0} + v\big|_{i=0}$$

$$(R_1 \| R_2)i \qquad \frac{R_2}{R_1 + R_2} v_{\text{in}}$$

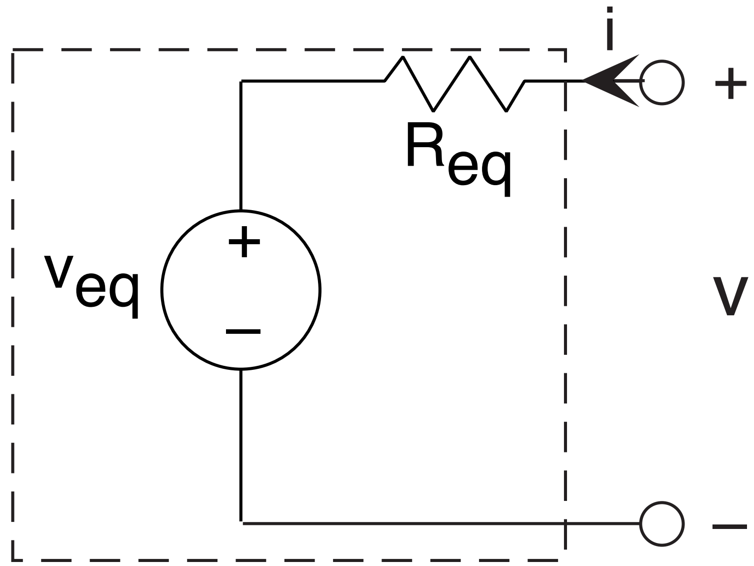


$$v = (R_1 \| R_2)i + \frac{R_2}{R_1 + R_2} v_{\text{in}}$$

But There's More!



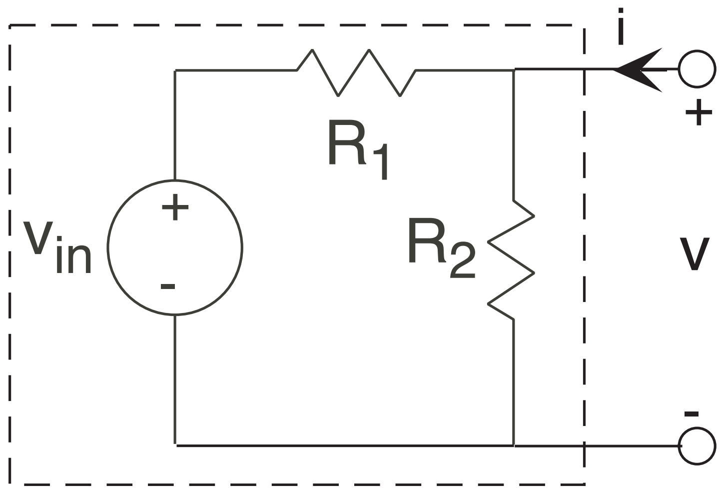
$$v = \underbrace{(R_1 \| R_2)}_{R_{\text{eq}}} i + \underbrace{\frac{R_2}{R_1 + R_2} v_{\text{in}}}_{v_{\text{eq}}}$$



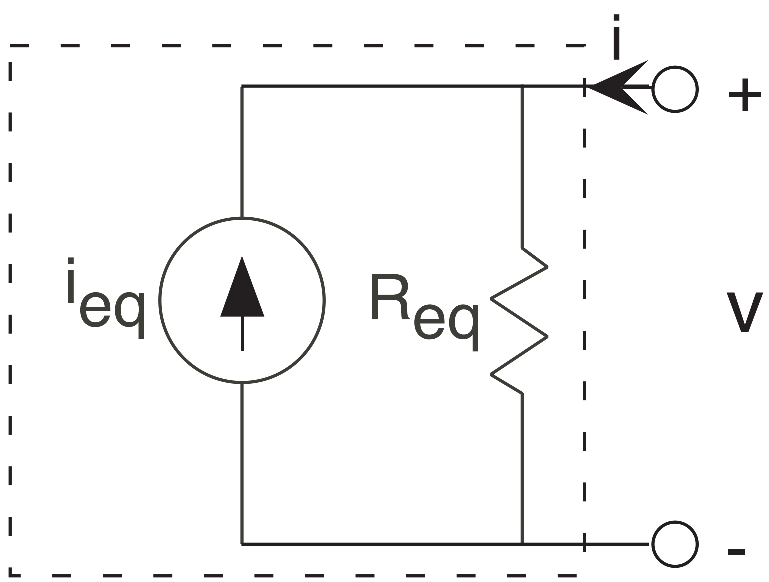
$$v = R_{\text{eq}} i + v_{\text{eq}}$$

Thévenin equivalent circuit

But There's Even More!



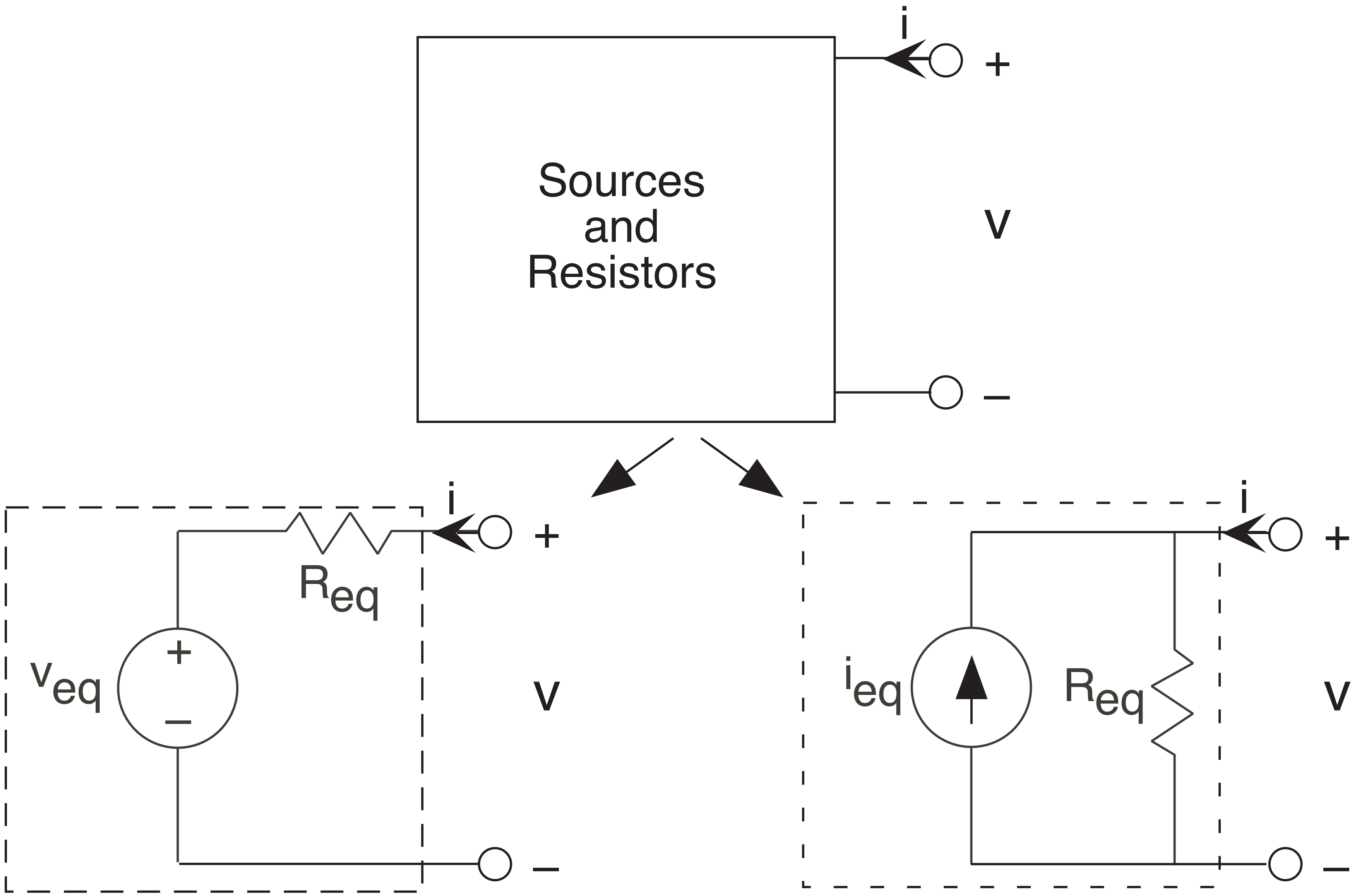
$$v = R_{\text{eq}} i + v_{\text{eq}}$$



$$i = \frac{v}{R_{\text{eq}}} - \underbrace{\frac{v_{\text{eq}}}{R_{\text{eq}}}}_{i_{\text{eq}}}$$

Mayer-Norton equivalent circuit

Equivalent Circuits



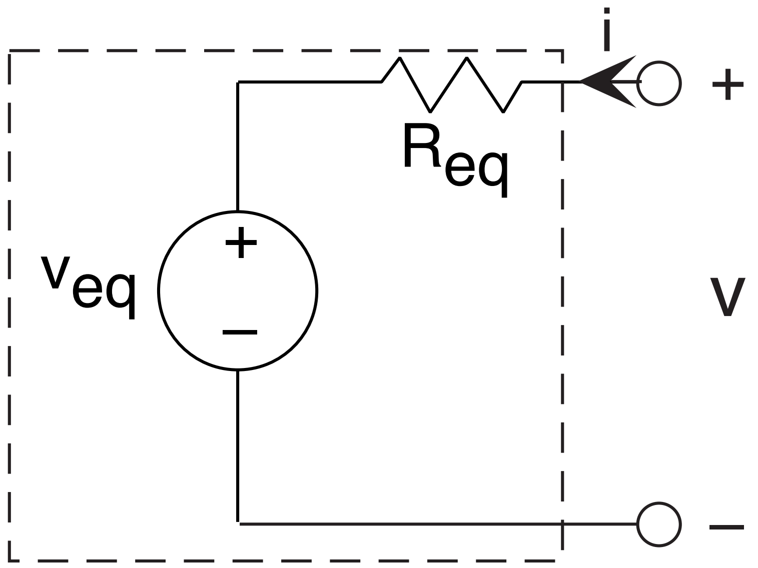
Thévenin Equivalent

Mayer-Norton Equivalent

$$v_{\mathrm{eq}} = R_{\mathrm{eq}} i_{\mathrm{eq}}$$

Finding Equivalent Circuits

How do you find the equivalent circuit without "looking inside"?



Open-circuit voltage: Connect nothing to the terminals

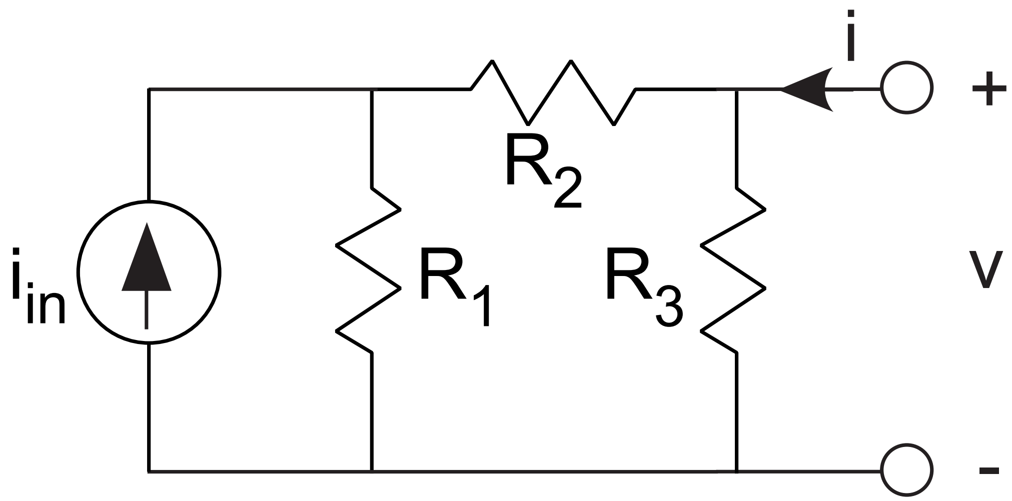
$$i = 0 \implies v_{\text{oc}} = v_{\text{eq}} = R_{\text{eq}} i_{\text{eq}}$$

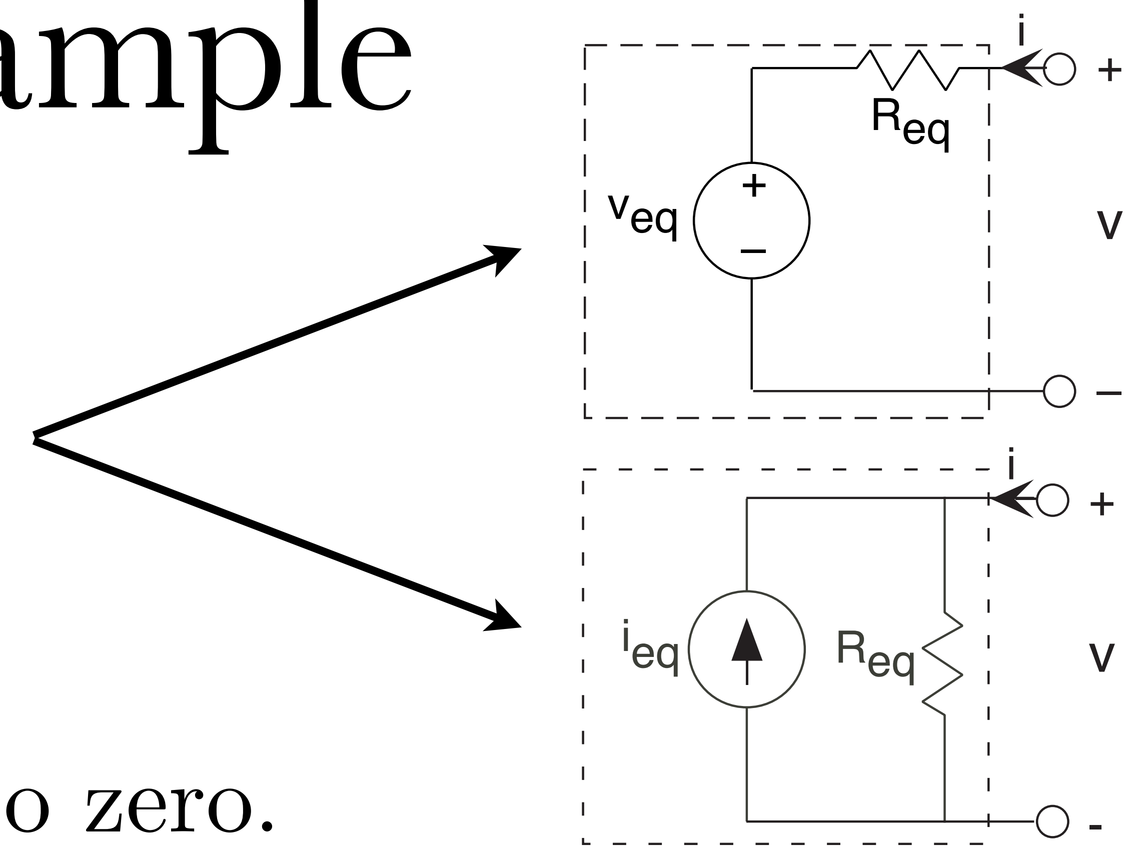
Short-circuit current: Connect a wire to the terminals

$$v = 0 \implies i_{\text{sc}} = -\frac{v_{\text{eq}}}{R_{\text{eq}}} = -i_{\text{eq}}$$

If you can "turn off" the sources, the resistance viewed from the terminals is R_{eq}

Example





To find R_{eq}, set source(s) to zero.

$$i_{\text{in}} = 0\colon\ R_{\text{eq}} = R_3 \| (R_1 + R_2)$$

To find v_{eq}, find open-circuit voltage.

$$i = 0\colon\ v_{\text{oc}} = R_3 \cdot \frac{R_1}{R_1 + R_2 + R_3} i_{\text{in}} = v_{\text{eq}}$$

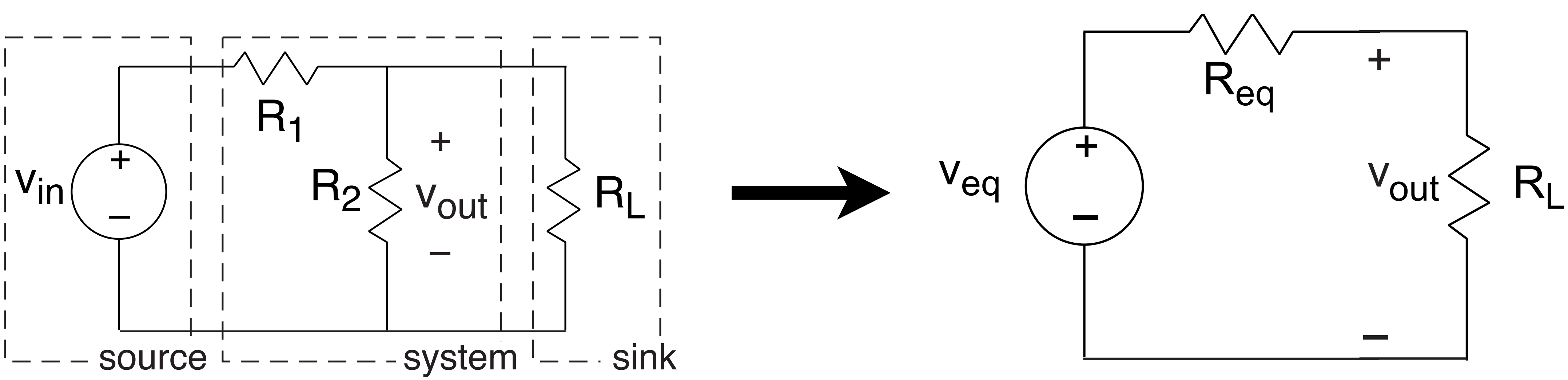
To find i_{eq}, find short-circuit current.

$$v = 0\colon\ i_{\text{sc}} = -\frac{R_1}{R_1 + R_2} i_{\text{in}} = -i_{\text{eq}}$$

RICE

Equivalent Circuits

- *All* circuits consisting of sources and resistors are equivalent to one source in series/parallel with one resistor
- Thévenin and Mayer-Norton equivalent circuits
- Remember "loading"?



$$v_{\text{out}} = \frac{R_L}{R_{\text{eq}} + R_L} v_{\text{eq}}$$