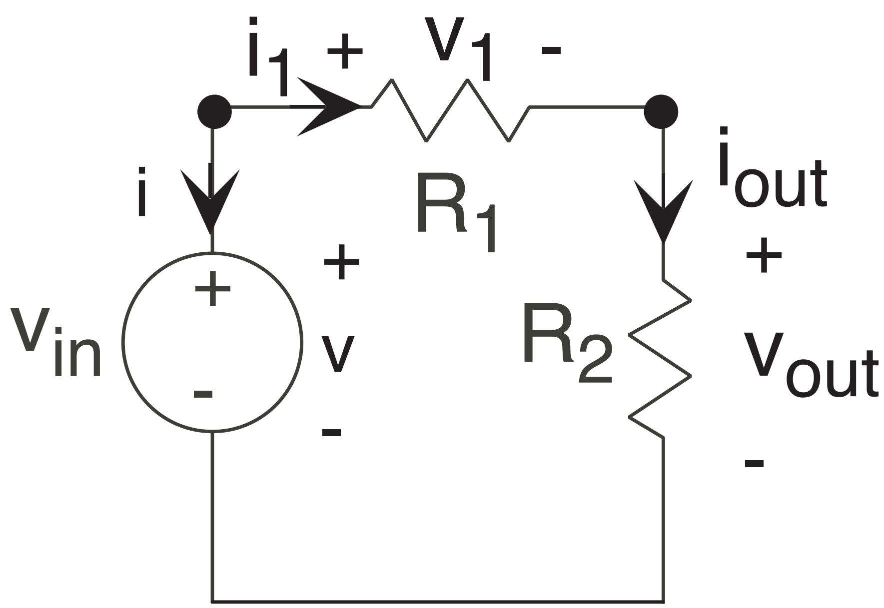
Fundamentals of Electrical Engineering

Equivalent Circuits

- What does a source "see"?
- Series and parallel combinations

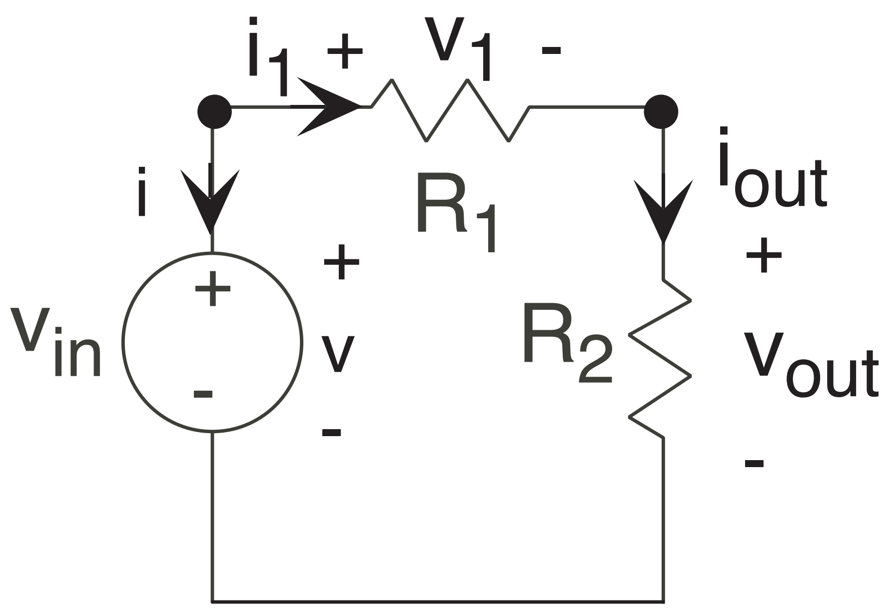
Our Simple Circuit



$$v_{\text{out}}(t) = \frac{R_2}{R_1 + R_2} v_{\text{in}}(t)$$

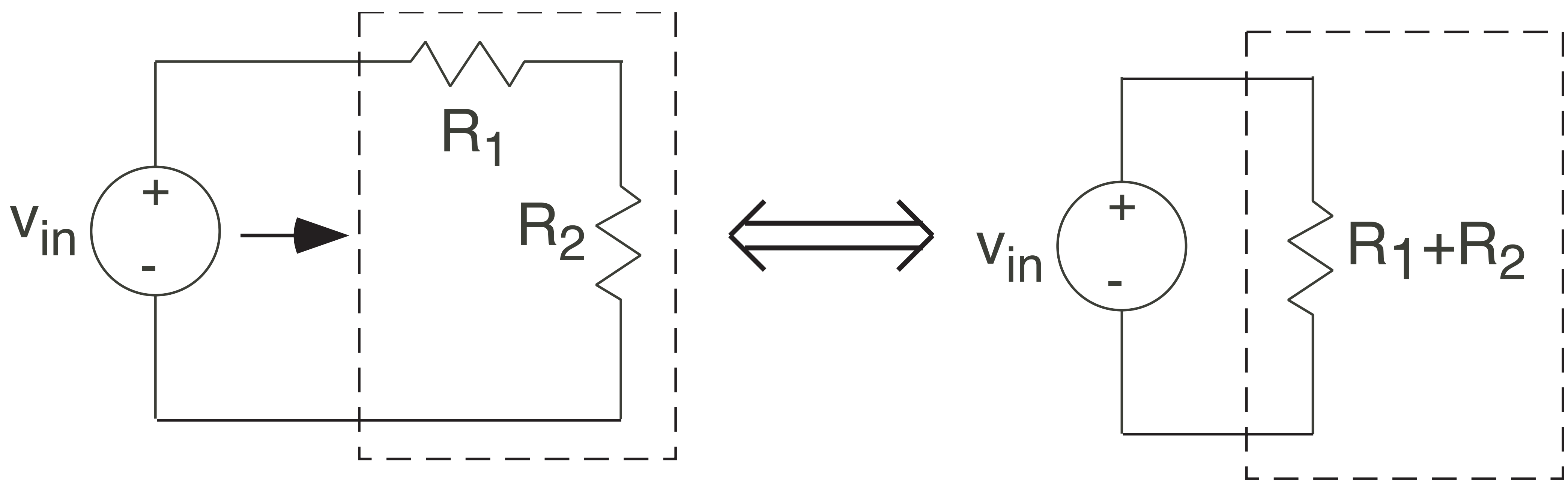
voltage divider

Our Simple Circuit



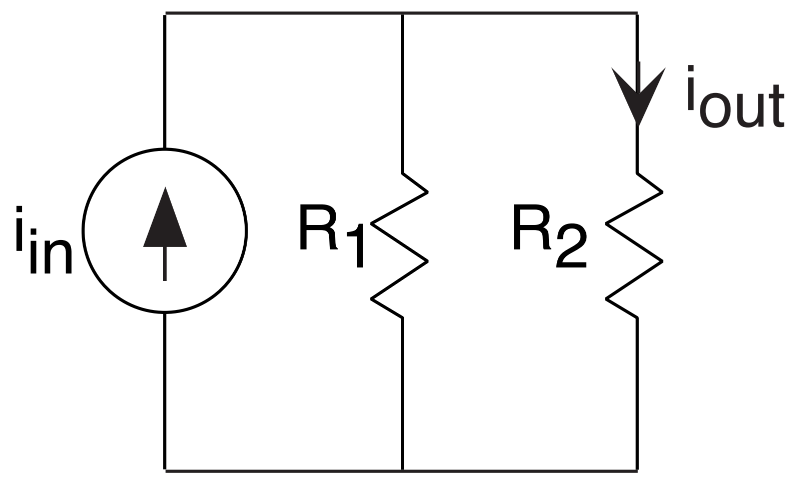
$$v_{\text{out}}(t) = \frac{R_2}{R_1 + R_2} v_{\text{in}}(t)$$

$$i_1 = \frac{v_{\text{in}}}{R_1 + R_2}$$



Resistors in series appear to be a *single* resistor, the value of which is the sum of the component values

Another Simple Circuit



v-i: $v_1 = R_1 i_1$

$v_2 = R_2 i_{\text{out}}$

KCL: $i_{\text{in}} = i_1 + i_{\text{out}}$

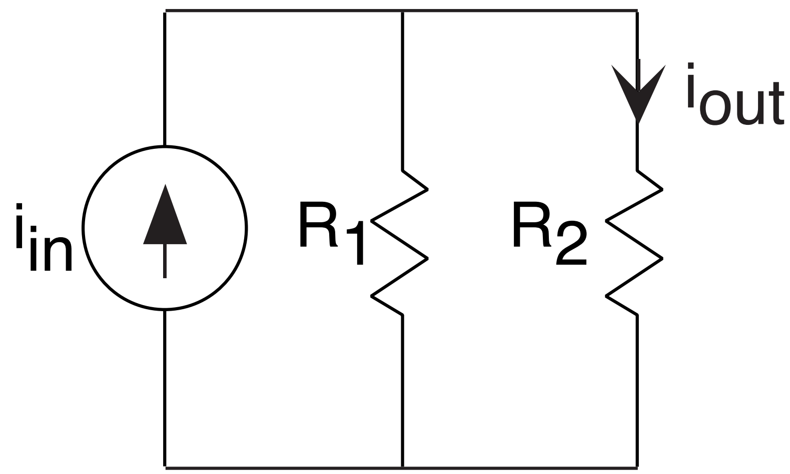
KVL: $v = v_1$

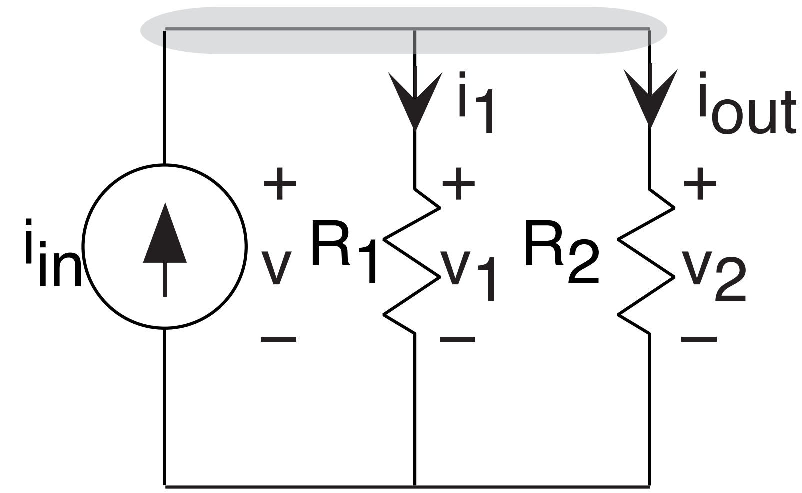
$v_2 = v_1$

$$i_{\text{out}} = \frac{R_1}{R_1 + R_2} i_{\text{in}}$$

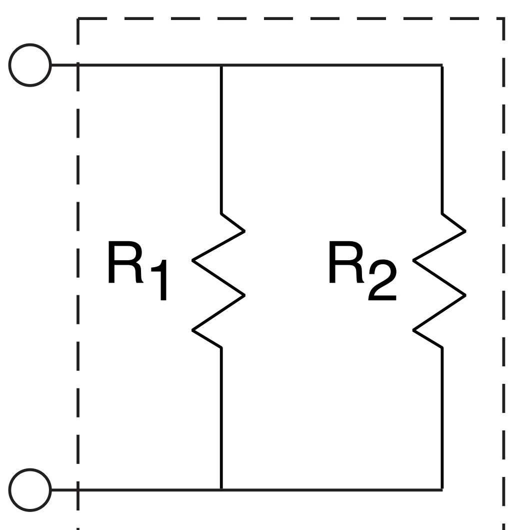
current divider

Another Simple Circuit

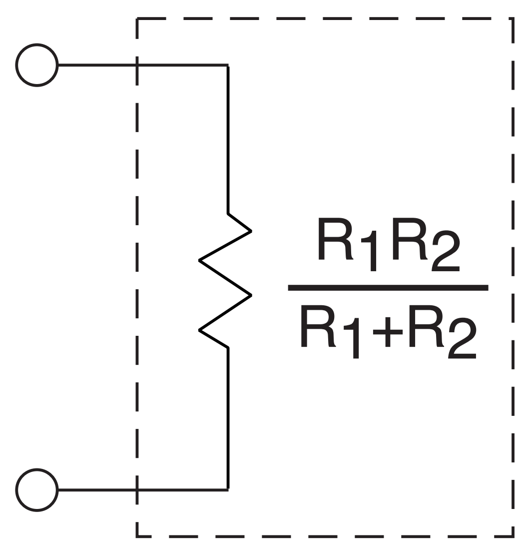




$$i_{\text{out}} = \frac{R_1}{R_1 + R_2} i_{\text{in}} \Longrightarrow v = v_2 = \frac{R_1 R_2}{R_1 + R_2} i_{\text{in}}$$

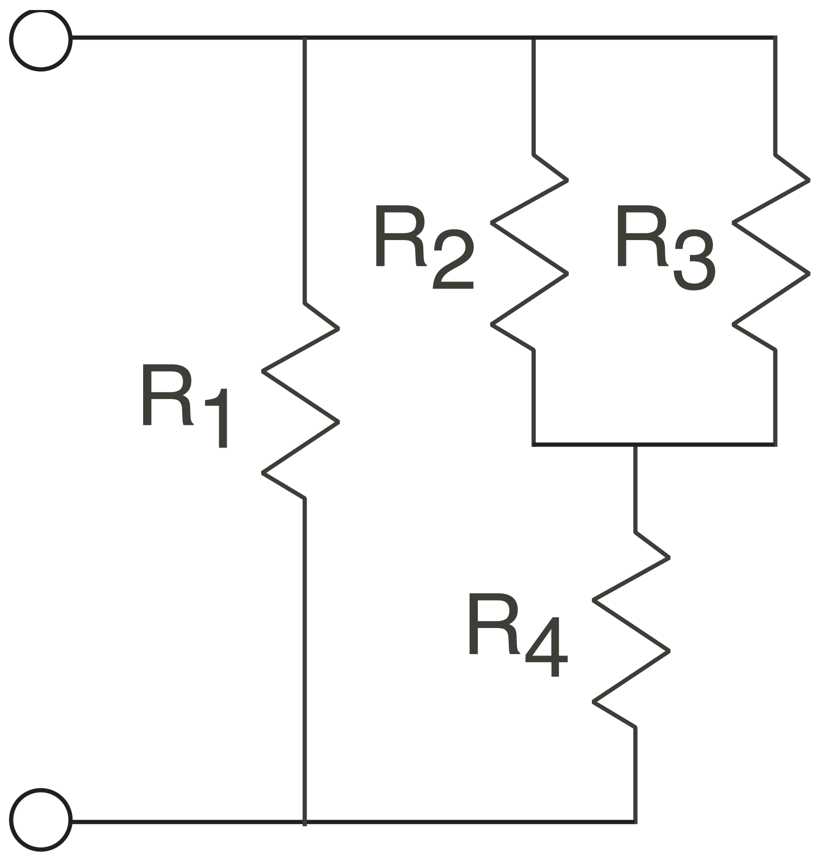


$\Longleftrightarrow$



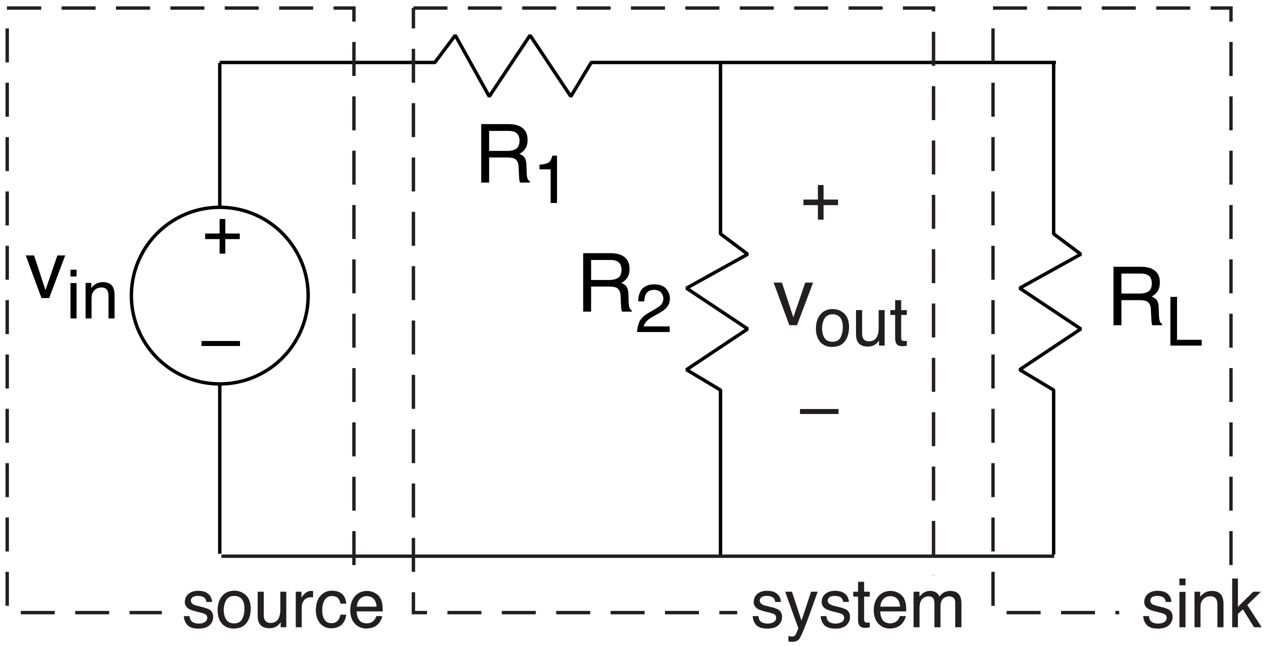
$$R_1 \| R_2 \equiv \frac{R_1 R_2}{R_1 + R_2}$$

Using Equivalent Resistance



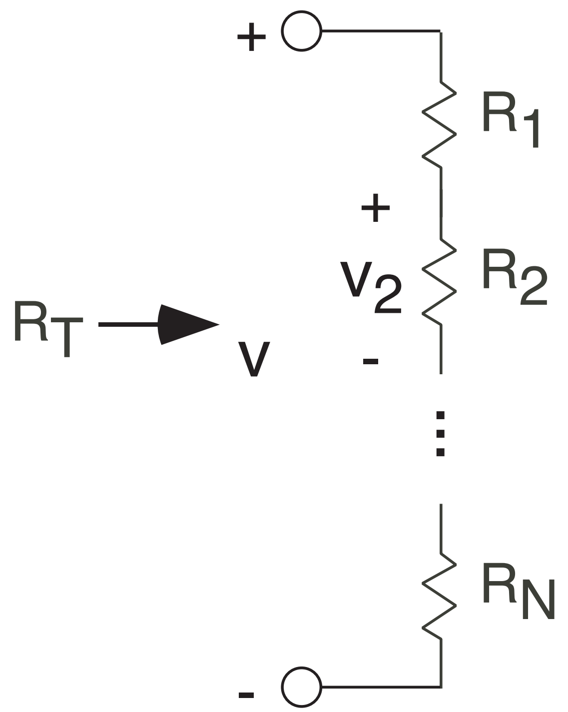
$$R_1 \| (R_2 \| R_3 + R_4)$$

Solving a Circuit "the Easy Way"

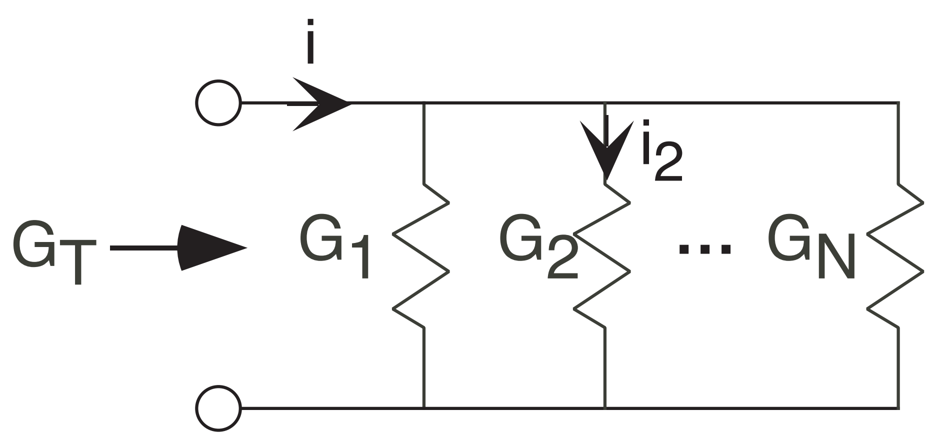


$$
\begin{aligned}
v_{\text{out}} &= \frac{R_2 \| R_L}{R_1 + R_2 \| R_L} v_{\text{in}} \\
&= \frac{\frac{R_2 R_L}{R_2 + R_L}}{R_1 + \frac{R_2 R_L}{R_2 + R_L}} v_{\text{in}} \\
&= \frac{R_2 R_L}{R_1 R_2 + R_1 R_L + R_2 R_L} v_{\text{in}}
\end{aligned}
$$

Resistor Equivalents



$$R_T = \sum_{n=1}^{N} R_n \qquad v_2 = \frac{R_2}{R_T} \cdot v$$



$$G_T = \sum_{n=1}^{N} G_n \qquad i_2 = \frac{G_2}{G_T} \cdot i$$

Solving Circuits

- Equivalent resistance, along with voltage and current divider, allows us to *easily* solve any circuit with resistors and sources
- Structure of a circuit: where are the series and parallel combinations?