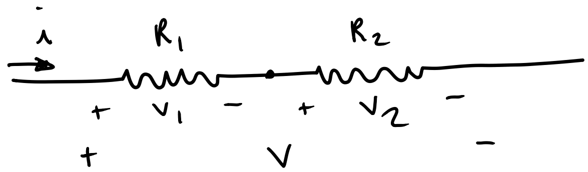
Equivalent Resistive Circuit

- Start with a network of resistors, and end with a single equivalent circuit

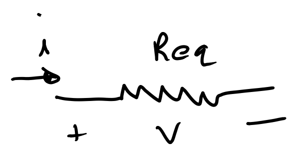
<u>Resistors in Series</u>
- Have the same current



$$V = v_1 + v_2$$

$$v = iR_1 + iR_2$$

$$v = i\underbrace{(R_1 + R_2)}_{R_{eq}}$$

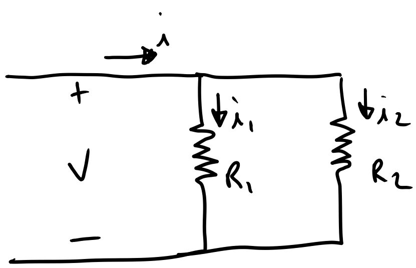


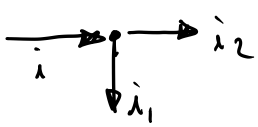
$$v = i R_{eq}$$

In General:

$$\boxed{R_{eq} = \Sigma R}$$

<u>Resistors in Parallel</u>
- Have the same voltage





<u>KCL</u>

$$-i + i_1 + i_2 = 0$$

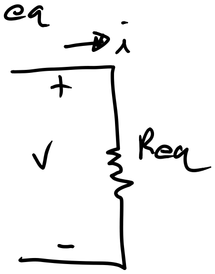
$$i = i_1 + i_2$$

$$i = i_1 + i_2 \qquad v = iR \Rightarrow i = \frac{v}{R}$$

$$i = \frac{v}{R_1} + \frac{v}{R_2}$$

$$i = v\left(\frac{1}{R_1} + \frac{1}{R_2}\right)$$

$$v = i\underbrace{\left(\frac{1}{R_1} + \frac{1}{R_2}\right)^{-1}}_{R_{eq}}$$



In General:

$$R_{eq} = \left[\Sigma\left(\frac{1}{R}\right)\right]^{-1} \quad \text{or} \quad \frac{1}{R_{eq}} = \Sigma \frac{1}{R}$$

For Two Resistors:

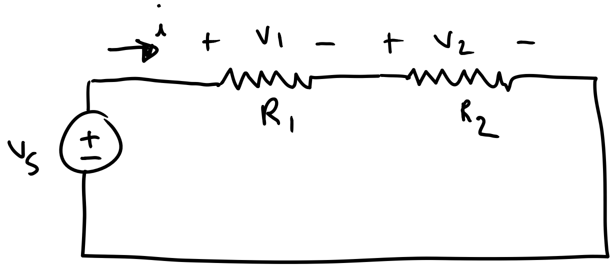
$$R_{eq} = \left(\frac{1}{R_1} + \frac{1}{R_2}\right)^{-1}$$

$$= \left(\frac{R_2}{R_1R_2} + \frac{R_1}{R_1R_2}\right)^{-1}$$

$$= \left(\frac{R_1 + R_2}{R_1R_2}\right)^{-1}$$

$$\boxed{R_{eq} = \frac{R_1R_2}{R_1 + R_2}}$$

Voltage-Divider Circuit



KVL (CW)

$$-v_s + v_1 + v_2 = 0$$

$$-v_s + iR_1 + iR_2 = 0$$

$$-v_s + i(R_1 + R_2) = 0$$

$$i = \frac{v_s}{R_1 + R_2}$$

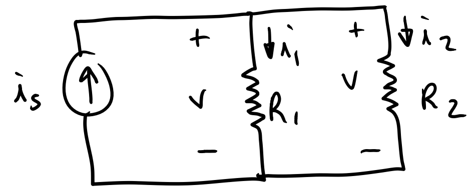
$$v_1 = iR_1 = \left(\frac{v_s}{R_1 + R_2}\right)R_1$$

$$\boxed{v_1 = \left(\frac{R_1}{R_1 + R_2}\right)v_s}$$

$$v_2 = iR_2 = \left(\frac{v_s}{R_1 + R_2}\right)R_2$$

$$\boxed{v_2 = \left(\frac{R_2}{R_1 + R_2}\right)v_s}$$

Current-Divider Circuit



KCL

$$-i_s + i_1 + i_2 = 0$$

$$i_s = i_1 + i_2$$

$$i_s = \frac{v}{R_1} + \frac{v}{R_2}$$

$$i_s = v\left(\frac{1}{R_1} + \frac{1}{R_2}\right)$$

$$v = \left[\frac{1}{R_1} + \frac{1}{R_2}\right]^{-1} i_s$$

$$v = \left(\frac{R_1 R_2}{R_1 + R_2}\right) i_s$$

$$i_1 = \frac{v}{R_1} = \left(\frac{R_1 R_2}{R_1 + R_2}\right) i_s \left(\frac{1}{R_1}\right)$$

$$\boxed{i_1 = \frac{R_2}{R_1 + R_2} i_s}$$

$$i_2 = \frac{v}{R_2} = \left(\frac{R_1 R_2}{R_1 + R_2}\right) i_s \left(\frac{1}{R_2}\right)$$

$$\boxed{i_2 = \frac{R_1}{R_1 + R_2} i_s}$$