Kirchoff's Laws

Voltage Law: Energy is conserved.

- around any circuit loop, charges gain no overall energy.
- Energy gained from EMF will be lost to resistance.
- The sum of all P.D. around a loop must be zero.

Current Law: Charge is conserved

- circuit neither creates/destroys charge
- current flows 'smoothly' through the circuit
- at any junction, sum of currents in + currents out = 0

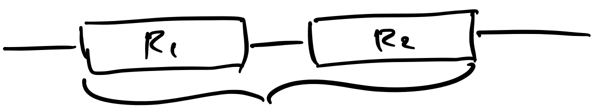
$$\sum V = 0 \qquad \sum I = 0$$

Equivalent Resistance

We can combine parallel and series resistors into a single equivalent resistance to simplify circuit analysis.

Series

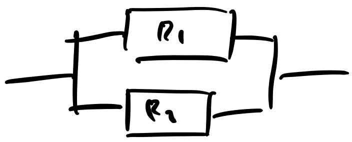
$$R_T = R_1 + R_2 + R_3 + \ldots + R_n$$



$R_T = R_1 + R_2$

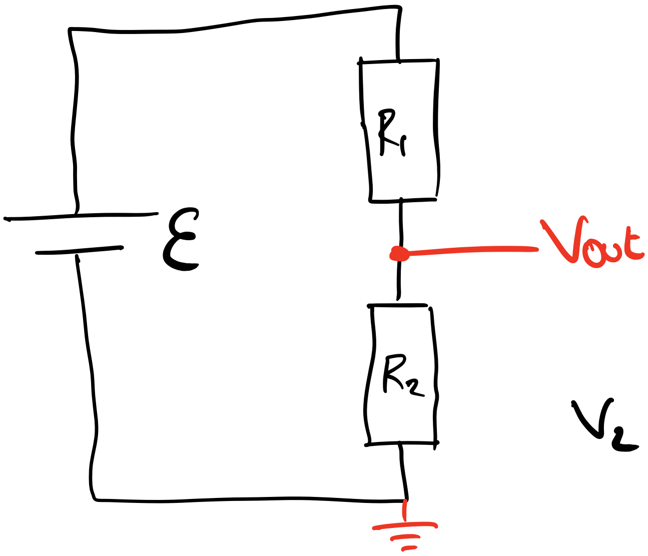
Parallel

$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \ldots + \frac{1}{R_n}$$



$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2}$$

Voltage divider: two resistors in series



$$I = \frac{\varepsilon}{R_1 + R_2}$$

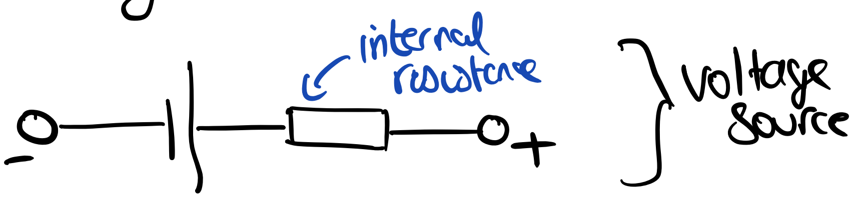
$$V_{out} = \frac{R_2}{R_1 + R_2} \cdot \varepsilon$$

$$V_2 = IR_2$$

$$V_2 = \frac{R_2}{R_1 + R_2}\varepsilon \qquad V_1 = \frac{R_1}{R_1 + R_2}\varepsilon$$

Internal Resistance

A real world voltage source has some series resistance r.



Unless indicated on diagram, assume voltage sources are ideal.

$$V = \varepsilon - Ir$$

Measurement Devices

Voltmeter: parallel to component. Ideal voltmeter has infinite resistance. In reality, r is large but not infinite.

Ammeter: series in circuit. Ideal ammeter has zero resistance. In reality, r is very small $\neq 0$.

loading - when the measurement device affects the measurement we're trying to make.