Electric circuit elements

- **Batteries** — devices that maintain a constant electrical pressure difference across their terminals (like a water pump that raises water to a certain height).
- **Resistances** — devices that have significant drag and oppose current. Pressure will drop across them.
- **Capacitors** — devices that can maintain a separation of charge if there is a potential difference maintained across the,
- **Wires** — have very little resistance. We can ignore the drag in them (mostly — as long as there are other resistances present).
Foothold ideas: Kirchhoff’s principles

1. **Flow rule**: The total amount of current flowing into any volume in an electrical network equals the amount flowing out.

2. **Ohm’s law**: in a resistor, \( \Delta V = IR \)

3. **Loop rule**: Following around any loop in an electrical network the potential has to come back to the same value (sum of drops = sum of rises).

---

Very useful heuristic

- The Constant Potential Corollary (CPC)
  - Along any part of a circuit with 0 resistance, then \( \Delta V = 0 \), i.e., the voltage is constant since in any circuit element

\[
\Delta V = IR \\
R = 0 \Rightarrow \Delta V = 0 \\
\text{(even if } I \neq 0) 
\]
Electric Power

- The rate at which electric energy is depleted from a battery or dissipated (into heat or light) in a resistor is

\[ \text{Power} = I \Delta V \]

Units

- Current \((I)\)  \(\text{Ampere} = \text{Coulomb/sec}\)
- Voltage \((V)\)  \(\text{Volt} = \text{Joule/Coulomb}\)
- E-Field \((E)\)  \(\text{Newton/Coulomb} = \text{Volt/meter}\)
- Resistance \((R)\)  \(\text{Ohm} = \text{Volt/Ampere}\)
- Capacitance \((C)\)  \(\text{Farad} = \text{Volt/Coulomb}\)
- Power \((P)\)  \(\text{Watt} = \text{Joule/sec}\)
Series and parallel

- **Series**
  - Same current flows through both devices
  - $I = \frac{\Delta V_A}{R_A} = \frac{\Delta V_B}{R_B}$
  - $\frac{\Delta V_A}{\Delta V_B} = \frac{R_A}{R_B}$
  - $\Delta V = \Delta V_A + \Delta V_B$
  - $= I(R_A + R_B)$

- **Parallel**
  - Same voltage drop across both devices
  - $\Delta V = I_A R_A = I_B R_B$
  - $\frac{I_A}{I_B} = \frac{R_B}{R_A}$
  - $I = I_A + I_B$
  - $\Delta V = \frac{1}{R_A} \frac{1}{R_B}$
  - $\Delta V = \Delta V \left( \frac{1}{R_A} + \frac{1}{R_B} \right)$