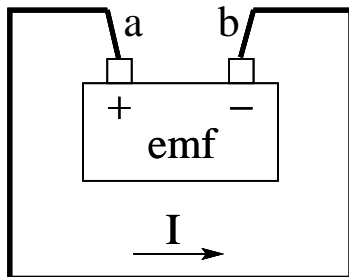# Battery with Internal Resistance
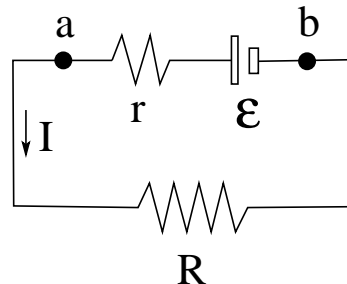
- Real batteries have an internal resistance r.

- The terminal voltage $V_{ba} \equiv V_a - V_b$ is smaller than the emf $\mathcal{E}$ written on the label if a current flows through the battery.

- Usage of the battery increases its internal resistance.

- Current from loop rule: $\mathcal{E} - Ir - IR = 0 \quad \Rightarrow \quad I = \dfrac{\mathcal{E}}{R + r}$

- Current from terminal voltage: $V_{ba} = \mathcal{E} - Ir = IR \quad \Rightarrow \quad I = \dfrac{V_{ba}}{R}$

physical system   circuit diagram   electric potential