

# 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:  $\mathcal{E} - Ir - IR = 0 \Rightarrow I = \frac{\mathcal{E}}{R + r}$
- Current from terminal voltage:  $V_{ba} = \mathcal{E} - Ir = IR \Rightarrow I = \frac{V_{ba}}{R}$

