CIRCUITS DAY 9: REAL BATTERIES, INTERNAL RESISTANCE & METERS

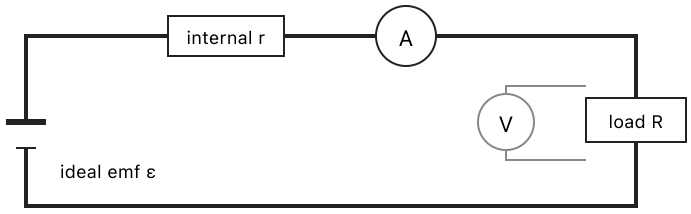
CED 11.5 · Skill 1.B · FRQ: ED

PREDICT BEFORE OBSERVING

Measure a battery with the circuit open, then connect a low-resistance load. Circle one for the loaded terminal voltage: **larger / smaller / unchanged**.

Observation source: battery, safe load, and voltmeter; projected PhET *Circuit Construction Kit: DC*; or the printed graph prediction.

REAL-BATTERY MODEL



EMF AND TERMINAL VOLTAGE

$$V_{terminal} = \varepsilon - Ir$$

While a battery supplies current, its internal resistance produces an internal potential drop.

NOTES / REASONING

CALCULATE THE LOADED STATE

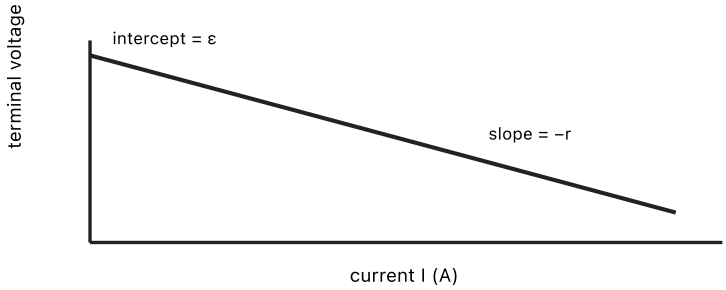
WE DO A battery has $\varepsilon = 9.0\ \text{V}$, $r = 0.80\ \Omega$, and supplies $0.75\ \text{A}$. Find the internal drop and terminal voltage.

YOU DO The same battery has terminal voltage $8.0\ \text{V}$ at $1.25\ \text{A}$. Infer r.

This sign applies while the battery supplies current. Charging cases are outside today’s model.

TERMINAL VOLTAGE AS A GRAPH

PLOT TERMINAL V VERTICALLY AGAINST I HORIZONTALLY



The y-intercept is ε. The slope is $-r$, with units $\mathrm{V/A} = \Omega$.

READ A line has intercept $9.0\ \mathrm{V}$ and passes through $(1.75\ \mathrm{A}, 7.6\ \mathrm{V})$. Find r.

METERS AND LOADING

An ideal ammeter has zero resistance and belongs in series. An ideal voltmeter has infinite resistance and belongs in parallel.

Real meters have finite resistance and alter the circuit slightly. Analyze meter loading only with stated finite resistances.

Safety: never place a current-mode meter directly across a source.

1. Find terminal V for ε=6.0 V, r=0.50 Ω, I=1.2 A.

2. Explain why a heavier load lowers terminal voltage.