A REAL, NON-IDEAL BATTERY

Recorder_____ Manager_____

Skeptic_____ Energizer_____

Real vs. ideal circuit elements

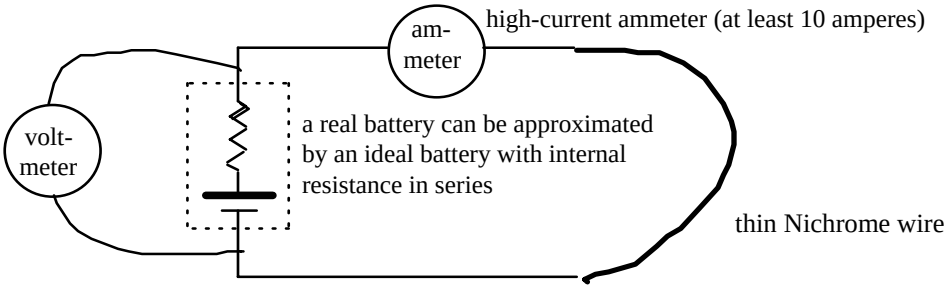
- For an "ideal", ohmic resistor, $\Delta V_{res} = RI$ with R constant, no matter how big the current through the resistor is. In an earlier circuit experiment, you found that the resistance of a light bulb was different when it was dim and when it was bright, so the light bulb was not an ideal ohmic resistor.
- Similarly, for an "ideal" battery, ΔV_{batt} is always equal to the emf (determined by chemical reactions).
- However, due to resistance inside the battery, ΔV_{batt} of a real battery is not always equal to emf.
- A real battery can be modeled approximately by treating it as an ideal battery in series with "internal resistance" r_{int} as shown in the diagram below, so $\Delta V_{batt} = \text{emf} - r_{int} I$.

Battery properties you will determine in this experiment:

- You will determine the internal resistance r_{int} of your battery.
- You will determine the maximum current your battery can deliver.
  (An ideal battery could theoretically deliver infinite current, which is impossible.)

- Assemble a series circuit as shown in the diagram with one battery, a high-current ammeter capable of handling 10 amperes, and a long thin Nichrome wire. Place a voltmeter to read the potential difference across the battery.

You MUST use the 10 ampere connections on the ammeter!
Do not make the final connections until your instructor has checked your circuit.



- Vary the length of the thin Nichrome wire by sliding the contacts, thereby changing its resistance.
- Don't burn yourself on the hot wire!
- Observe the behavior of the potential difference ΔV_{batt} across the battery as the current I increases.
- Explain this briefly and qualitatively in terms of the model for a real battery that $\Delta V_{batt} = \text{emf} - r_{int} I$:

As I increases, what happens to ΔV_{batt}?
Why? Explain briefly.

Is ΔV_{batt} greater than, equal to, or less than emf?

If we can determine the emf we can use measurements of ΔV_{batt} and I to determine r_{int}.

Determine the emf

- If $I = 0$, ΔV_{batt} = emf–0 = emf. Measure the emf of the battery by making I be equal to 0.

emf = How did you make I be zero?

Is your value for the emf consistent with the approximate value printed on the battery?

Measure ΔV_{batt} when there is a large current

- Remove the resistive Nichrome wire and get ready to connect the ammeter directly to the battery.
- VERY BRIEFLY, so as not to deplete the battery too much, measure ΔV_{batt} and the large current I.

I = ΔV_{batt} =

Is ΔV_{batt} equal to the emf of this real, non-ideal battery?

Determine the internal resistance of the battery

- Use your data to calculate the internal resistance of the battery. Show your calculations.
- Remember, the potential difference across a real battery is $\Delta V_{batt} = \text{emf} - r_{int}I$, not $\Delta V = RI$.

r_{int} =

(Show calculations)

Calculate the maximum current the battery can deliver

- Now that you know the internal resistance of the battery, calculate the maximum possible current this battery can deliver. (Hint: What is the minimum possible ΔV_{batt}?)

I_{max} =

(Show calculations)

A footnote: What is the resistance of the ammeter?

- The ammeter has some resistance, which is why the current you observed was less than I_{max}.
- You have enough data to determine the resistance of the ammeter. What is $R_{ammeter}$?

$R_{ammeter}$ =

(Show calculations)

Check your work with a neighboring group, then both groups check with instructor.
The instructor will look for all questions having been addressed. Turn in report.