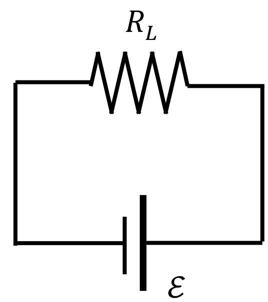
Section	Group	Name	Signature
Grade			

Materials: • PhET Circuit Construction Kit: DC

After this activity you should know: *• the difference between an ideal and real EMF • internal resistance • how the voltage between the EMF terminals depend on load resistance.*

IDEAL EMF: An ideal EMF always produces the same voltage difference across the terminals. The terminal voltage of a real battery, however, decreases as the current increases. This decrease is negligible if the load resistance is large but becomes important when the load resistance is comparable to the internal resistance of the battery.



Build the circuit shown with the single resistor and ideal battery (zero battery resistance). Set the EMF to 30 Volts and the load resistance R_L to 120 Ω. Use the ammeter and voltmeter to measure the current through, and the voltage across the battery. Calculate the power provided by the EMF and fill in entries in the table. Repeat measurements for other load resistances in the table.

Ideal EMF:

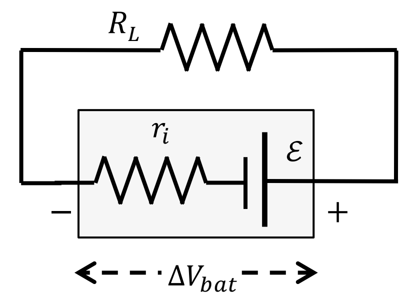
Resistance	120 Ω	10 Ω	1 Ω	0.5 Ω
ΔV_{batt}	30V	30 V	30 V	30V
I_{batt}	0.25 A	3 A	30 A	59.99 A
P_{batt}	7.5W	90 w	900 w	1799.7W

What is the power provided by the ideal EMF if we shorted the ideal battery by a wire with a very small resistance of 0.01 Ω?

$P = \frac{v^2}{R} = \frac{30^2}{.01} = 90,000$

What would the power provided by the battery be if connected a superconductor (zero resistance) across the leads of the ideal battery? Is this not sensible?

undefined. Its not sensible b/c you are dividing by 0



Model of Real EMF: To model a real battery, we treat the battery as an ideal EMF $\mathcal{E}$, in series with an internal resistance r_i. The ideal EMF always generates the same ideal voltage difference $\mathcal{E}$ but, due to the internal resistance, the voltage across the actual battery terminals will be smaller than $\mathcal{E}$ when there is a current.

Keep the EMF at 30 V but click on the battery resistance box and set it equal to 2 Ω. This is the internal resistance of the model of a "real" battery.

Open Circuit Voltage: Remove the load resistor so that there is a gap in the circuit. Measure the voltage across, and current through the "real" battery (of the current should be zero). Fill in entries on table. This is voltage is called the open circuit voltage of the EMF and is equal to the ideal EMF.

Put the load resistor back into the circuit and complete the table below.

Model of Real EMF:

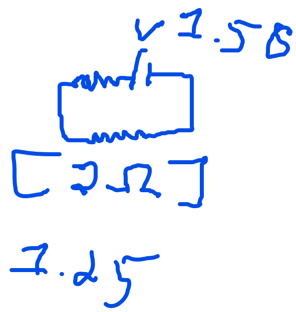
Resistance	open circuit	120 Ω	60 Ω	10 Ω	1 Ω	0.5 Ω	0.0 Ω
ΔV_{batt}	30V	29.51V	29.03V	25V	10 V	6V	0V
I_{batt}	0 A	0.25 A	0.48 A	2.5 A	10 A	12A	15 A
P_{batt}	0W	7.4W	13.9W	62.5W	100W	72 W	0

When is it a reasonable approximation to treat a real battery as an ideal EMF?

Around 1 Ω of Resistance.

Here is some real data for a real AA battery has an open circuit voltage of 1.58 V. When a 2Ω resistor is placed across the battery terminals, the voltage across the battery is reduced to 1.25 V. What is the internal resistance of the battery?[1]

$\frac{1.25}{2}$



0.528 ~~A~~ Ω

[1] *Note that the internal resistance of a battery will increase as the battery is drained.*