

3.C.1 - Batteries, Direct Current, and the Ampere.



Battery Construction

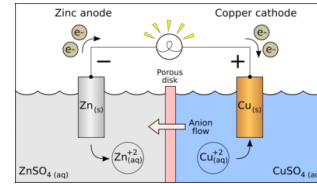
A battery converts chemical potential energy to electrical potential energy.

Two major components:

Electrolytes – Fluid that conducts electric charge.

Electrodes – Metals that contact the electrolyte.

Chemical reactions on the electrode surface generate the battery's potential.



Electrode Details

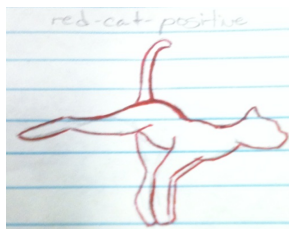
Anode – Negative terminal of a battery.

Cathode – Positive terminal of a battery.

Different metals in electrolytes will have different electric potentials.



Wait, not THAT kind of electrode!



Electromotive Force (EMF)

EMF: (Analogous to voltage) Potential difference between battery terminals when NOT connected to a circuit.

Represents maximum voltage of a battery.

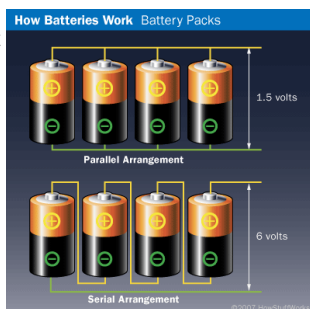
Voltage measurement will drop as battery is hooked up to circuit.

Ever seen your lights dim when something turned on?

Back EMF: Voltage established in electric motors that counteract applied voltage.

Battery Configurations

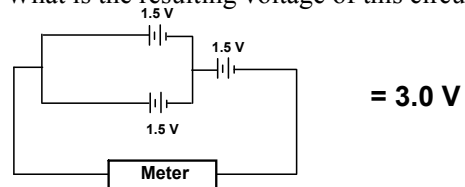
The voltage of parallel batteries equals the battery with the highest voltage, and if voltages are different then the lower voltage batteries are charged by the higher one.



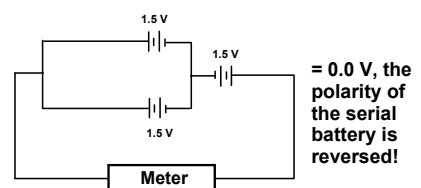
The voltage of batteries in series is additive.

Battery Example

What is the resulting voltage of this circuit?



How about this one?



Current

Electric current (in equations: 'I') is a rate of charges moving past a point in space over some duration of time.

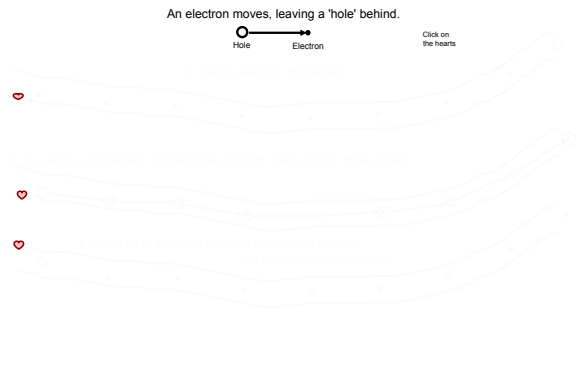
$I = \frac{\Delta Q}{\Delta t}$ AP Equation	Q = charge (C) t = time (s)
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Charges can be positive or negative; but in electric circuits they are electrons (protons are stationary).

Unit of current is the Ampere (A), 1 A = 1 C/s
 Note: I (not impulse, or moment of inertia!) is from French "intensité", the French word for "current".

Hole Current

Historically, circuit analysis has been in terms of conventional current (or hole current), opposite electron movement.



Question!

How fast do you think that electrons travel through conducting wires?

It doesn't take long for the lights to come on when you flick a switch, does it?

Drift Velocity

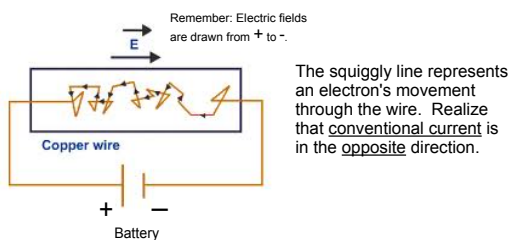
It turns out that electrons actually travel slowly through conductors.

Drift velocity is on the order of 1 mm/s.
 With no voltage across a conductor, delocalized electrons move randomly with no net displacement.
 With a voltage, electrons still move randomly, but with a net movement toward the positive terminal.

Electric Fields

While electrons drift slowly, electric fields propagate at speeds approaching that of light.

This is why the light bulb comes on as soon as you flick the switch.

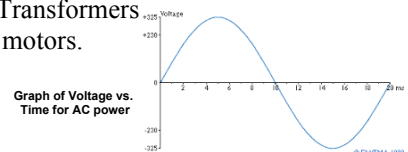


Types of Current

Depending on the power supply, electric current will be direct, or alternating.

Alternating Current (AC): Current driven by an alternating voltage supply. Here in North America, our power is at a 60 Hz oscillation cycle.

Applications: Transformers (change voltage), motors.



Direct Current (DC): Current driven by a battery or rectified AC supply.

Applications: Electronic circuits.

Examples

What is the current if 4.5 coulombs of charge passes through a wire in 20.8 s?

$$I = \frac{\Delta Q}{\Delta t} = \frac{4.5 C}{20.8 s} = 0.22 A$$

How long would it take 9.50 coulombs of charge to pass through a wire if the current is 15.0 mA?

$$I = \frac{\Delta Q}{\Delta t}$$

$$\Delta t = \frac{\Delta Q}{I} = \frac{9.5 C}{1.5 E - 2 A} = 633 s$$

Historical Footnote

Thomas Edison was a strong proponent of direct current, while Nikola Tesla worked extensively on alternating current systems.



Edison

Tesla

Tesla worked for Edison for a while, and after a major falling out involving one of Tesla's innovations, resigned and worked for Westinghouse.

Both inventors have lasting legacies, and their disagreements, personal and scientific, are best summarized in this video clip.

<http://www.youtube.com/watch?v=gJ1Mz7kGVf0>

Electric Circuits

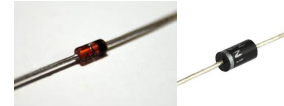
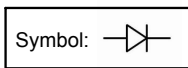
Def. A path in which electrons from a voltage or current source flow. This path can have any number of differently functioning components.



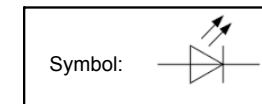
Example circuit board(s).

Circuit Components & Symbols

Diodes - allow current to flow one direction

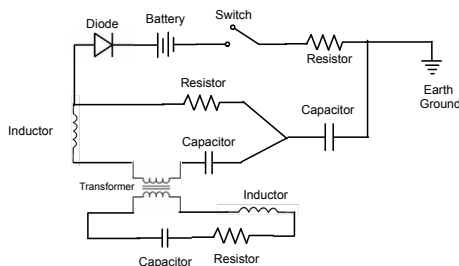


Light Emitting diodes - make light as they allow one-way current.



Circuit Example

Identify the components of this circuit:



Homework

3.C.1 Problems.
Due: Next Class.

Unit 3.C Review Problems 1 & 2
Due: End of Unit 3.C