AP Phys 1 Unit 11.2 Notes - Current

11.2 Electric Current and Drift Velocity

Current (Symbol = I)

Def: a rate of charges moving past a point over some time, analogous to water moving through a pipe in a water system.

$I = \frac{\Delta q}{\Delta t}$ AP Equation	q = Charge (C) t = time (s)

Moving charges can be either positive or negative, although realistically in electric circuits the charges are electrons (protons are stationary).

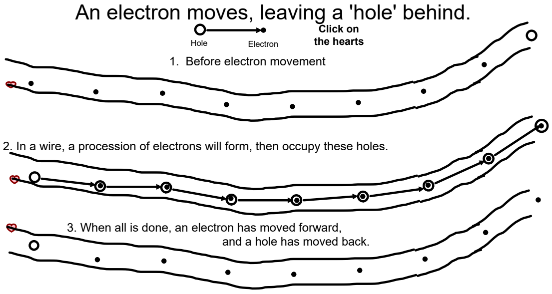
Unit of current is the Ampere (A), 1 A = 1 C/s

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 (positive, or hole current), opposite electron movement. This is due to that "positive test charge" again, and Franklin's arbitrary assignment of positive and negative.

An electron moves, leaving a 'hole' behind.



1. Current Democracy!

How fast do you think electrons travel through conducting wires?

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

Slowly: mm/s	Moderately: m/s	Smokin' Fast: km/s	Light Speed

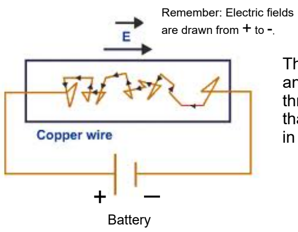
Drift Velocity

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.



The squiggly line represents an electron's movement through the wire. Realize that conventional current is in the opposite direction.

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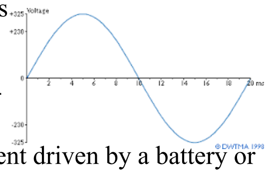
Types of Current

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.



Graph of Voltage vs. Time for AC power

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

Applications: Electronic circuits.

Examples

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

$$I = \frac{q}{t} = \frac{4.5\,C}{20.8\,s} = 0.22\,A$$

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

$$I = \frac{q}{t}$$

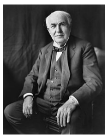
$$t = \frac{q}{I} = \frac{9.5\,C}{1.5E-2\,A} = 633\,\text{s}$$

4. If the current were 2.5 amps, how much charge would flow in 1.4 seconds?

$$I = \frac{q}{t} \rightarrow q = I \bullet t = 2.5\frac{C}{s} \bullet 1.4\,s = 3.5\,C$$

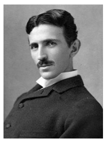
Historical Footnote

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



Edison

Vs.



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

Battery Ratings

Batteries are rated in terms of how much charge they can produce during their useful lives.

Units for this are Ampere-hours (A•h), and are calculated by multiplying an average current by the time duration:

$$\boxed{Ampere\ hours = I \bullet t}$$

5. How many hours could a 0.5 A-h battery run for with a current of 0.04 A?

$$Ampere\ hours = I \bullet t$$

$$t = \frac{A \bullet h}{I} = \frac{0.5\,A \bullet h}{0.04\,A} = 12.5\,hours$$

Homework

11.2 Problems.

Due: Next class