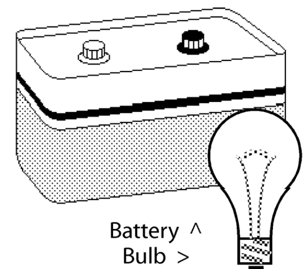
PhyzGuide: Circuit Basics

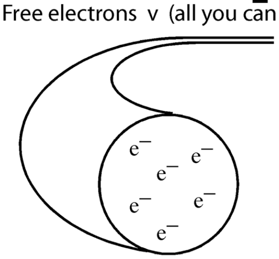
Anyone who has ever seen lightning knows that electricity can be extremely powerful and dangerous. And yet we use electricity to power our lights and appliances. How? So far we've learned about charge, the force between charged objects, the fields created by charged objects, and the electric potentials associated with charged objects. Pretty esoteric material. We may understand Coulomb's law, electric fields and voltage, but what do these things have to do with how a toaster works? The answer lies in the *electric circuit*.

THE PLAYERS

A simple electric circuit involves two main components: a source of electric potential and an energy-consuming device. For our discussion of a simple circuit, we will consider a battery for our source of electric potential and a light bulb for our energy-consuming device (a resistor).



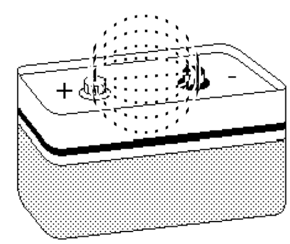
Battery ^
Bulb >
Free electrons v (all you can eat)



The "life-blood" of an electric circuit is *free-moving electric charge*. This is not a component or something that has to be added to a battery or lightbulb—it already exists throughout the circuit. Electric circuits are constructed of metal—usually copper. The chemical bonds that hold copper atoms (or those of other metals) together do not involve all the electrons in the atoms; the "leftover electrons" are needed in the metal to keep it electrically neutral, but are free to go anywhere in the metal: they are **free electrons.**

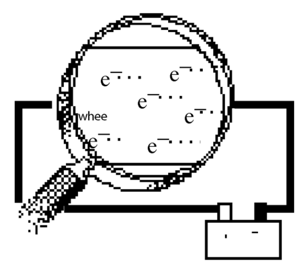
THE PROCESS

The goal is to make the bulb light up. The bulb will emit light only if the filament gets very hot. One way to make the filament hot is to force electrons through it (the electrons jostle the atoms in the filament, jostled atoms jiggle more, jiggling atoms are "hot" atoms).



A weak electric field between the terminals of a battery

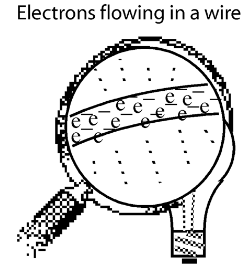
A chemical reaction inside the battery results in one terminal of the battery becoming negatively charged and the other positively charged. This creates a weak electric field between the terminals. Electrons are repelled by the negative terminal and attracted to the positive terminal. Electrons sitting on the negative terminal are like apples hanging from a tree. Apples have potential energy associated with the gravitational force that attracts them to the ground. Electrons have potential energy associated with the electric force that attracts them to the positive terminal. The amount of potential energy each coulomb of charge has (the electric potential) depends on the chemical reaction occurring in the battery. We say that this chemical reaction "creates a potential difference across the terminals." We rate batteries by the potential differences they can sustain—for example, there is a 1.5 V potential difference between the terminals of zinc/carbon and alkaline batteries.



Electrons flowing in a wire

Potential difference or electric potential (energy per charge) is commonly known as **voltage.** Voltage is what drives the electrons from the negative to the positive terminal. But electrons will flow only if a conducting path, such as copper wire, connects the terminals. The wire concentrates the electric field between the terminals, and electrons in the wire flow readily.

But don't forget the bulb! Now that we have a way of getting electrons to move, we can force them through the filament as part of their journey to the positive terminal. The potential energy they must lose on this journey is converted by the bulb into heat and light, as described above (way above, at the beginning of this section).



In the thin filament, electrons pile up and give up energy