Unit 2
Current Electricity

Section 1: Electric Current (Text 14.2)

In this lesson you will

- define and write a mathematical relationship for current (I) in terms of charge (q) and time (t)
- do numerical exercises to determine I, q or t
- explain the term ***conventional current***
- draw a simple schematic circuit to show how current is measured

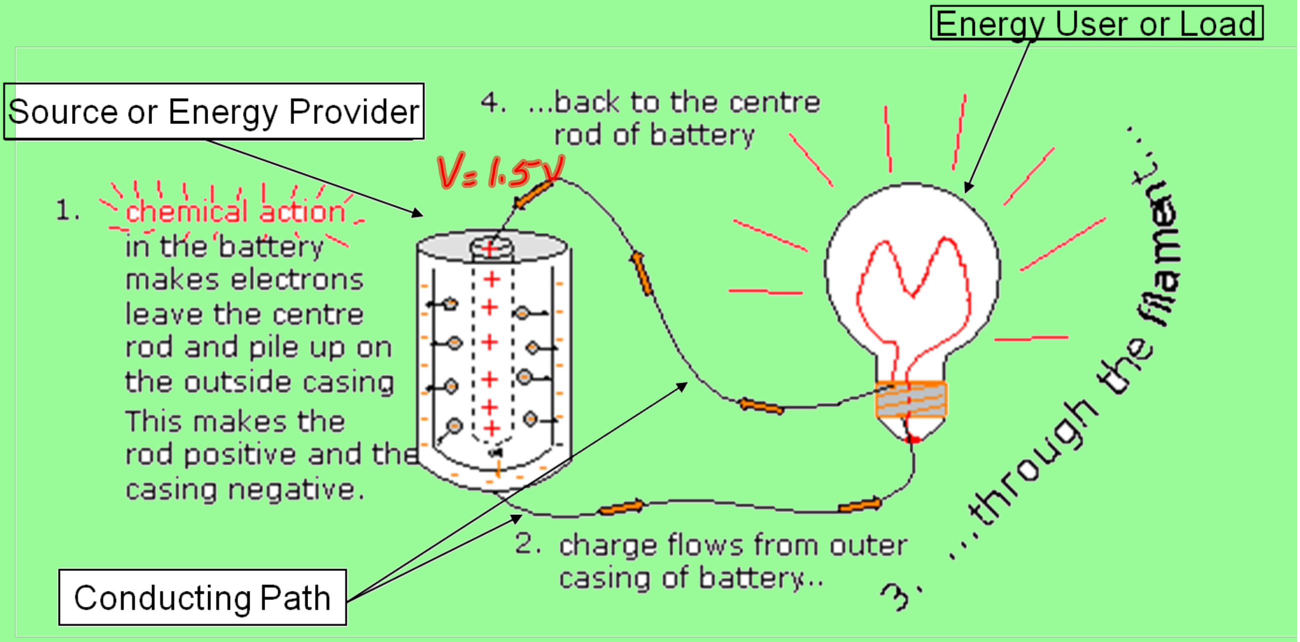
Static electricity - electrons (or electricity) at rest

Electrons sometimes move from one material to another when the two materials are rubbed together. This movement occurs during a very short period of time. Once they have moved, they settle down in an equilibrium way on the surface. After the initial movement, all electrons cease motion.

Current electricity - movement of charged particles along a path
- generally associated with a source of charges and the conducting path

In the next few lessons you will read about charge that is always on the move. A simple example is the case where the charge operates the small bulb in a flashlight. The complete story is told in the picture below.

Just recall from the last few lessons that electrons will flow from where there are a lot of them (they repel each other) to where there are very few. The fancy way of say that is **electrons flow from regions of high potential to regions of low potential** (something like a rock falling from a location of high potential to a location of lower potential).



For the electrons, the casing is at a higher potential than the rod. Therefore if a path is provided, the electrons will run "downhill" to the top of the rod. (Later you will learn more about the potential energy **gain** in the battery and the potential energy **loss** in the lamp.)

The wire provides the path and the **charge flows** causing a **current.**

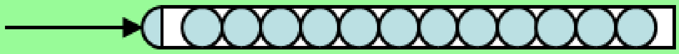
Current is the rate of flow of charge.

But we have put an obstacle in the path. Another name for obstacle is **resistance**. The filament of the lamp is the resistance, and as the electrons fight their way through the filament, they lose their energy.

Electrons gain their energy in the battery. Their energy comes from the chemical energy in the battery which "pumps them up to the top of the hill". The top of the hill is the casing of the battery. Electrons lose their energy in the bulb filament. The energy is emitted as heat and light (and sometimes the filament vibrates and you hear sound as well). No energy of the electrons is truly lost. The energy gained in the battery can all be accounted for in the heat, light and sound that is emitted in the filament. Of course, the wire path itself provides a little resistance and heat is emitted there as well. You can really notice this if you feel the wire going to an electric kettle that has been plugged in for a while.

BACK TO CURRENT

Current is the rate of flow of charge.

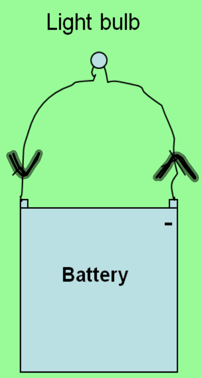


Moving charges is a lot like moving marbles through a narrow tube. As one is pushed in one end, all the marbles are forced to move at the same rate.

Marbles will arrive at the far end of the tube at the same time and at the same rate as they were introduced in the other.

Conventional Current

Benjamin Franklin reasoned That charge would move from an area of high concentration to one of lesser concentration. He reasoned that + represented The area of greatest Concentration and as such charge would flow from the + to the – terminal through the external circuit.



Electron Current

Later, after it was discovered that The electron was the primary carrier of electric charge we came to believe that the charge would move from the negative to the positive terminal. It is also easier for beginning students to follow this approach. This is the approach most generally accepted for early study nowadays.

Although not used extensively in an early study of electricity the ideas of conventional current is still used extensively with electronics and higher order study.

Therefore,

$$\textbf{Electric Current} = \frac{\textbf{Electric Charge}}{\textbf{time}} \quad \text{or} \quad I = \frac{Q}{t}$$

where **Q** is the electric charge in **Coulombs (C)**
t is the time in **seconds (s)**
I is the electric current in **Amperes (1 A = 1 C/s)**

Examples

1. If a current of 2.0 A is drawn through a filament of an electric light bulb for 10.0 s,
   (a) how many coulombs of negative charge would have moved passed any point in the filament during this time?

$I = 2A$
$t = 10s$
$Q = ?$

$I = \frac{Q}{t}$
$Q = It$
$Q = (2A)(10s)$
$= 20C$
$= 2.0 \times 10^1 C$

   (b) how many electrons does this correspond to?

$Q = Ne$
$N = \frac{Q}{e} = \frac{20C}{1.602 \times 10^{-19}}$
$= 1.2 \times 10^{20}$ electrons

2. What current exists in a wire in which 2.5 x 10 [19] electrons move past a point in 10.0 s?

$N = 2.5 \times 10^{19}$
$t = 10.0\,s$
$I = ?$
$Q = ?$

$Q = Ne$
$= (2.5 \times 10^{19})(1.602 \times 10^{-19}\,C)$
$= 4.0\,C$

$I = \frac{Q}{t} = \frac{4.0\,C}{10.0\,s} = 0.40\,A$

3. What quantity of charge will have moved past any one point in a wire carrying a current of 3.0 A during a 10.0 min interval? How many electrons will have passed this point in this time?

$Q = ?$
$I = 3.0\,A$
$t = 10.0\,min$
$= 600\,s$
$N = ?$

$Q = It$
$= (3A)(600s)$
$= 1800\,C$

$\left[\frac{C}{s} \cdot s\right]$

$N = \frac{Q}{e} = \frac{1800\,C}{1.602 \times 10^{-19}\,C}$
$= 1.1 \times 10^{22}$ electrons

4. How much current passes through a toaster if 1500 C of charge pass through it in 2.5 minutes?

$Q = 1500 C$
$t = 2.5 min$
$t = 150 s$
I

$I = \frac{Q}{t} = \frac{1500 C}{150 s} = 10 A$

5. If you have a clock radio on your night table, it probably draws about 5.0 x 10^{-2} A of current.How much charge passes through it while you sleep from 11:00 PM to 7:00 AM?

$I = 5.0 \times 10^{-2} A$
$t = 8 h \times \frac{3600 s}{h}$
$t = 28800 s$
Q

$Q = It$
$= (5 \times 10^{-2} A)(28800 s)$
$= 1440 C$

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