13b: Electric Current

When a conductor is connected between both terminals of a battery it forms an **electric circuit**.

- A **circuit** must be a complete, unbroken loop connecting one terminal of a battery (or other source of voltage) to the other.
- A battery is commonly shown in a **circuit diagram**, since they are easy to handle in real life and do not complicate the situations we will look at.
    - In the circuit diagrams (aka "***schematics***") a battery is shown as two parallel lines, one longer than the other. The **longer** line is the **positive** terminal and the **shorter** line is the **negative** terminal.

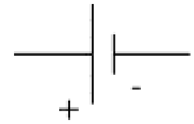

Figure 1: A battery shown in a circuit diagram.

The battery in a circuit will cause charge to flow from one terminal to another... this is called **electric current**.

- A more precise definition is the amount of charge that passes a given point in a certain amount of time.
- This leads to the basic formula for current that you will use:

$$I_{avg} = \frac{\Delta Q}{\Delta t}$$

I_{avg} = current in amperes (A)
ΔQ = charge in coulombs (C)
Δt = time in seconds (s)

Sometimes we use the shortened version of the name "amperes" in everyday language… "amps".

- It is named after the French physicist André Ampere (1775-1836).
    - He showed the relationship between electricity and magnetism, made a primitive type of electromagnet, and came up with the "right-hand" rules we will learn about soon.

Example 1: A current of 2.5 A flows through a wire connecting the terminals of a battery. After 4.00 minutes, how much charge has passed through the circuit?

$$I_{avg} = \frac{\Delta Q}{\Delta t}$$
$$\Delta Q = I_{avg} \Delta t$$
$$\Delta Q = (2.5\text{A})(240\text{s})$$
$$\Delta Q = 6.0\text{e}2\,C$$

Remember there are free electrons in conductors that can move around.

- When a conducting wire is attached to the terminals of a battery, it is actually the electrons that will move around.
    - This model of electric current is referred to as **electron flow current**.
- Two centuries ago when the ideas of current were first being worked out (by guys like Franklin), it was assumed that positive charges were moving.
    - This model of electric current is referred to as **conventional current**.
    - At least this agrees with our use of positive test charges earlier.

- The U.S.A. is one of the few countries that follows the **conventional current** model, even though they know that the **electron flow** model is more accurate.
  - For the AP exam (created in the USA), we always assume that we are using **conventional current** in questions unless we are told otherwise.
  - For everything that relates to content in Canada, we assume that we should use **electron flow**.

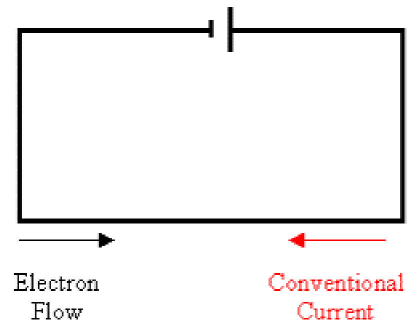

Illustration 1: Electron flow and conventional current move in opposite directions in a circuit.

In fact, both models have one weakness… they make it sound like the positive and negative charges actually move through the wires.

- In fact, all the electrons do is wiggle back and forth a bit.
- When it comes to solving problems involving electric current, either model works just about as well.
  - Whether we think of it as a proton (**conventional current**) or an electron (**electron flow**) moving around, it is always the same amount of charge (an elementary charge) that is being considered.
  - The only difference is that you get answers that say the current is flowing in opposite directions.