Introduction to Physical Science

Electric Current and Ohm's Law

Presented by Robert Wagner

Electric Current

- Defined as the rate at which charge flows
  -
  - SI unit: Ampere. 1 A = 1 C/s

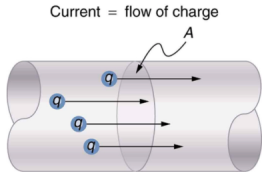

Figure 20.2 The rate of flow of charge is current. An ampere is the flow of one coulomb through an area in one second.

Image Credit: OpenStax College Physics - Figure 20.2 CC BY 4.0

Example

- What is the current involved when a truck battery sets in motion 720. C of charge in 4.00 s while starting an engine? How long does it take 1.00 C of charge to flow through a handheld calculator if a 0.300 mA current is flowing?
  - Draw a sketch (if applicable)
  - Identify known values
  - Identify equation
  - Enter values in the equation and solve

$$\Delta Q = 720.\ C\ ;\ \Delta t = 4.00\ s$$

$$I = \frac{\Delta Q}{\Delta t} = \frac{720.\ C}{4.00\ s} = 180.\ A$$

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

$$\Delta t = \frac{1.00\ C}{0.300x10^{-3}\ C/s} = 3.33x10^{3}\ s$$

Current Flow

- Schematic diagram
  - Can represent a wide variety of situations
- Current flow from positive to negative
  - Direction in which positive charges would flow
  - In most cases, it is the electrons that flow
  - The convention comes from the historical definition

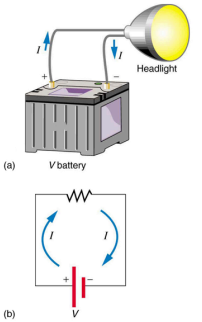

Image Credit: OpenStax College Physics - Figure 20.3 CC BY 4.0

Drift Velocity

- Electrons follow paths that appear random
  - In the presence of an electric field, the electrons will drift slowly
  - Drift velocity: v_d
- Drift velocity is very small
  - Order of 10^{-4} m/s
  - Take 3 hours to travel one meter

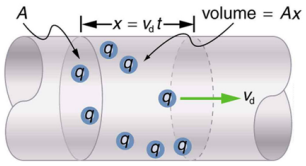

Figure 20.7 All the charges in the shaded volume of this wire move out in a time t, having a drift velocity of magnitude $v_d = x/t$. See text for further discussion.

Image Credit: OpenStax College Physics - Figure 20.7 CC BY 4.0

Ohm's Law

- The current in a metal is directly proportional to the voltage applied
  -
- The current is inversely proportional to the resistance
  -
- Ohm's Law
  -

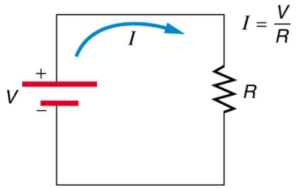

Image Credit: OpenStax College Physics - Figure 20.8 CC BY 4.0

Resistance

- Resistance is measured in Ohms
- 1 Ohm (Ω)= 1 Volt/1 Ampere
- Bands on the resistor are color coded to tell the amount of the resistance

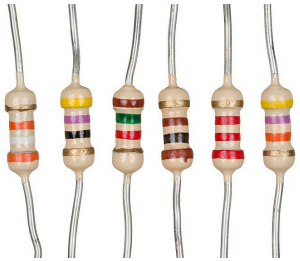

Image Credit: Evan-Amos, Public domain, via Wikimedia Commons

Example

- What is the resistance of an automobile headlight through which 2.50 A flows when 12.0 V is applied to it.
  - Draw a sketch (if applicable)
  - Identify known values
  - Identify equation
  - Enter values in the equation and solve

$$I = 2.50\,A\,;\; V = 12.0\,V$$

$$I = \frac{V}{R}\,;\; R = \frac{V}{I}$$

$$R = \frac{12.0\,V}{2.50\,A}$$

$$R = 4.80\,\Omega$$

Summary

- Electric current is defined as the rate at which charge flows
- The electrons move slowly through a wire at the drift velocity
- Ohm's law relates the current, voltage and resistance in a circuit