L 26 Electricity and Magnetism [3]

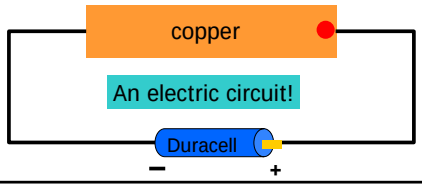
- Electric circuits
  - what conducts electricity
  - what doesn't conduct electricity
- Current voltage and resistance
  - Ohm's Law
- Heat in a resistor – power loss
- Making simple circuit connections

http://www.cnn.com/2005/US/10/31/pastor.electrocuted.ap/index.html

- **Pastor electrocuted while performing baptism**
- Monday, October 31, 2005; Posted: 5:12 a.m. EST (10:12 GMT)
- **WACO, Texas (AP) -- A pastor performing a baptism was electrocuted inside his church Sunday morning when he adjusted a nearby microphone while standing in water, a church employee said.**

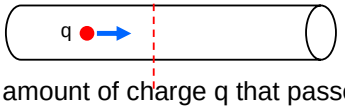
Current– flow of electric charge

If I connect a battery to the ends of the copper bar the electrons in the copper will be pulled toward the positive side of the battery and will flow around and around.
➔ this is called **current** – flow of charge



Electric current (symbol I)

- Electric current is the flow of electric charge q (Coulombs)



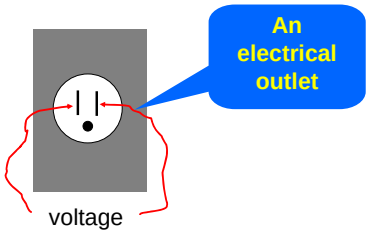
- It is the amount of charge q that passes a given point in a wire in a time t, $I = q \div t$
- Current is measured in amperes
- 1 ampere (A) = 1 C / 1 s

Potential difference or Voltage (symbol V)

- Voltage is what causes charge to move in a conductor
- It plays a role similar to pressure in a pipe; to get water to flow there must be a pressure difference between the ends, this pressure difference is produced by a pump
- A battery is like a pump for charge, it provides the energy for pushing the charges around a circuit

Voltage and current are not the same thing

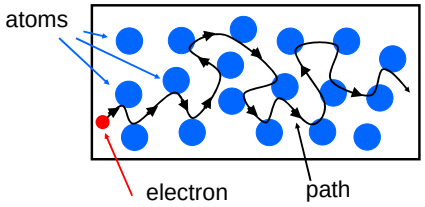
- You can have voltage, but without a path (connection) there is no current.



Electrical resistance (symbol R)

- Why is it necessary to keep pushing the charges to make them move?
- The electrons do not move unimpeded through a conductor. As they move they keep bumping into the atoms which either slows them down or bring them to rest
- This continuous opposition to the motion of the electrons is called **resistance**→ R

Electrons pass through an obstacle course in a conductor

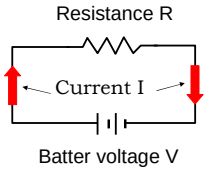


The **resistance (R)** is a measure of the degree to which the conductor impedes the flow of current. Resistance is measured in **Ohms** (Ω)

Current, Voltage and Resistance OHM'S LAW

- Ohm's law is a simple relation between these three important circuit parameters
- Ohm's law:
  - **I = Voltage/ Resistance = V / R**
  - V in volts, R in ohms, I in amps
- V = I R
- R = V / I

other forms of Ohm's Law



Examples

- (1) If a 3 volt flashlight bulb has a resistance of 9 ohms, how much current will it draw
  - I = V / R = 3 V / 9 Ω = 1/3 Amps
- (2) If a light bulb draws 2 A of current when connected to a 120 volt circuit, what is the resistance of the light bulb?
  - R = V / I = 120 V / 2 A = 60 Ω

Heat produced in a resistor

- The collisions between the electrons and the atoms in a conductor produce heat.
- The amount of energy converted to heat per second is called the power loss in a resistor
- If the resistor has a voltage V across it and carries a current I the power dissipated is given by → Power $P = I \times V$ or $I^2 \times R$

Heat produced in a resistor

- Power → P = I x V or I^2 x R
- Power is measured in **Watts = amps x volts**
- All wire is rated for the maximum current that it can handle based on how hot it can get
- To carry more current you need wire of a larger diameter → this is called the wire gauge, the lower the gauge the more current it can carry
- Using extension cords can be dangerous!

example

- How much current is drawn by a 60 Watt light bulb connected to a 120 V power line?
- **Solution:** P = 60 W = I x V = I x 120

  so I = ½ Amp (A)
- What is the resistance of the bulb?
- **Solution:** V = I R→ 120 V = ½ A x R

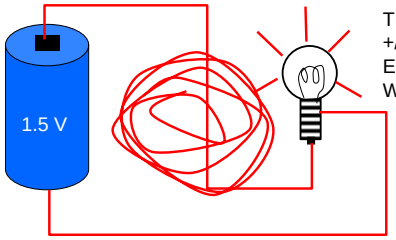
  so R = 240 Ω, or R = V/I

extension cords and power strips

- extension cords are rated for maximum current → you must check that whatever is plugged into it will not draw more current than the cord can handle safely.
- power strips are also rated for maximum current → since they have multiple imputs you must check that the total current drawn by everything on it does not exceed the current rating

Simple direct current (DC) electric circuits

Exercise: given a battery, some wire and a light bulb, connect them so that the bulb is on.

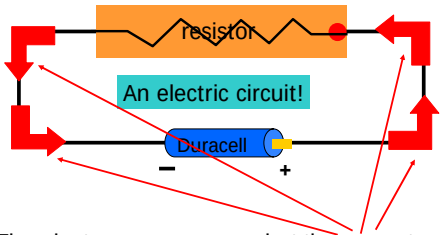


The battery polarity +/- does not matter, Either way the bulb Will be on.

Electric circuits

- a circuit must provide a closed path for the current to circulate around
- when the electrons pass through the light bulb they loose some of their energy → the conductor (resistor) heats up
- we refer to conductors as resistors because they impede (resist) the flow of current.
- the battery is like a pump that re-energizes them each time they pass through it
- the current flows in the direction that is opposite to the direction that the electrons travel (this is Ben Franklin's fault!).

Direction of current flow



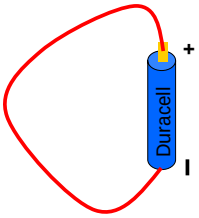
The electrons go one way but the current goes the other way by convention.

What is DC?

- With DC or direct current the current always flows in the same direction
- this is the type of current you get when you use a battery as the voltage source.
- the direction of the current depends on how you connect the battery
- the electricity that you get from the power company is not DC it is AC (alternating).

connecting batteries → do's and don'ts

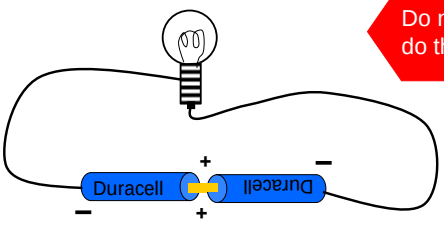
don't connect a wire from the + side to the – side, this shorts out the battery and will make it get hot and will shorten its lifetime.



Do not do this

dueling batteries

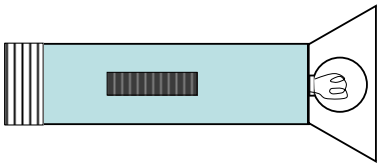
Do not do this



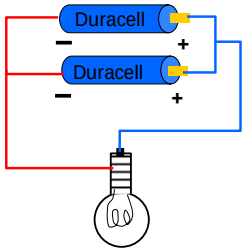
The batteries are trying to push currents in opposite directions → they are working against each other. This does not work.

Proper connections

Connecting two 1.5 volt batteries gives like this gives 3.0 volts.

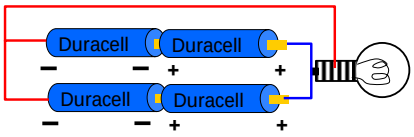


Batteries in parallel



This connection still gives 1.5 volts but since there are 2 batteries it will provide power for a longer time

Longer lasting power



This connection provides 3.0 volts and will provide power for a longer amount of time