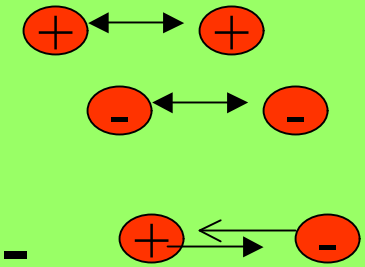
Notes on Current, Electrical Power, and Power Supplies

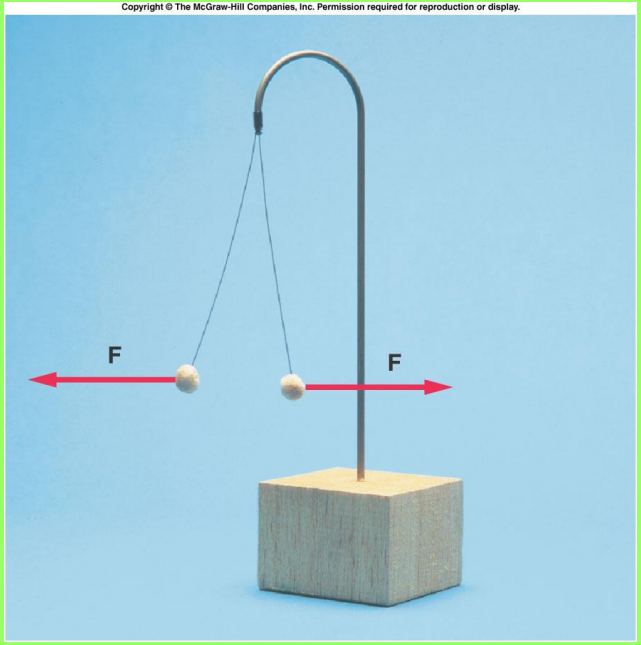
Charge

- Matter exists in one of 3 states of charge, positive, negative, or neutral.
- Like charges repel + +, - -
- Unlike charges attract: - + , + -
- These forces are called electrostatic forces



Charge from an Amber Rod.

Both pith balls are charged alike. They repel each other and push each other apart.



Charge Units

- The symbol for charge is q
- The unit of charge is the coulomb

Atoms are normally neutral

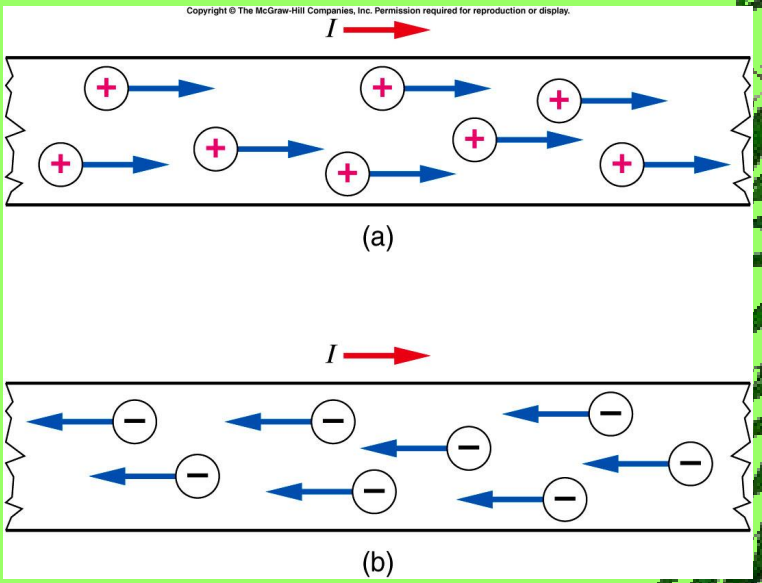
- Protons have + charge ($+1.6 \times 10^{-19}$ C)
- Electrons are negative (-1.6×10^{-19} C)
- Atoms have the same number of p's and e's
- An ion has more p's or e's
- Positive ion has more p's, negative ion more e's

Coulomb's Law

- $F = k\, q^1 q^2 / d^2$
- The force between electrical charges is proportional to the charge of each and inversely proportional to the square of the distance between them.

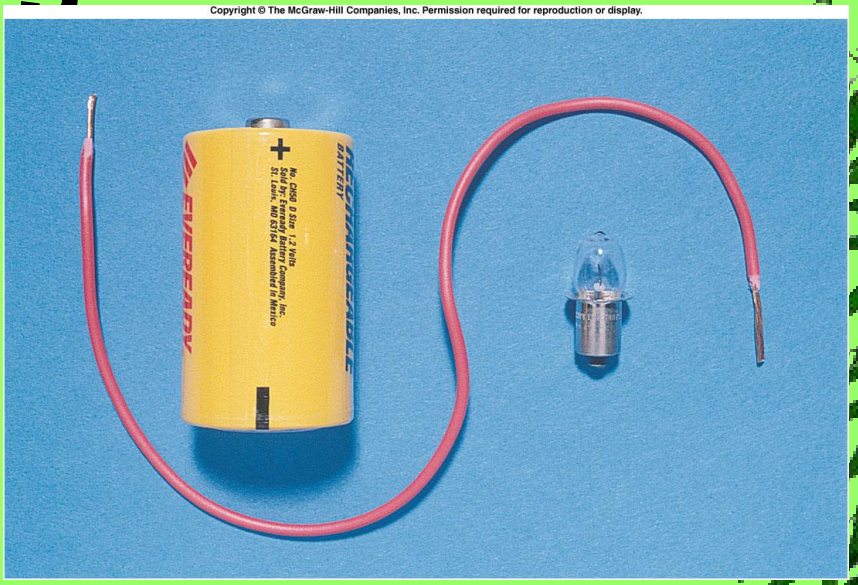
Current

- **Current:**A flow of charged particles across or through something. Usually electrons (negative charges) from negative terminal to ground or positive
- Letter **I** stands for the current. It is measured in **Amperes** (Coulombs/s)



Voltage

- **Voltage:** Force creating the current, abbreviated by the letter **V**, measured in **Volts**
- Common AA, AAA, C and D batteries have from 1.2 to 1.5 volts when new.



Conductors

- Substances which allow current to flow through them easily. E.G. metals: gold, silver, copper

Insulators

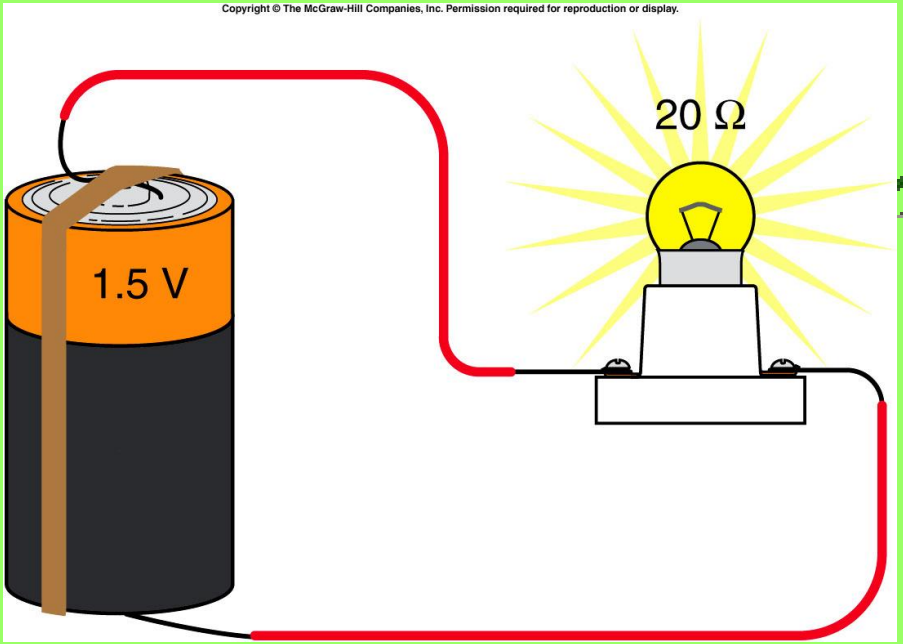
- **Insulators** are substances which do not allow the flow of current easily.
- Example wood, plastic, asbestos, sand, glass.

Battery = voltage

Wire = conductor

Red rubber = insulator

Lamp= resistor



Semiconductor

- **Semiconductors:** Substances which mildly resist current flow through them. Example silicon, germanium
- The understanding and use of semiconductors allowed the rapid spread of the electronics industry.

Resistance

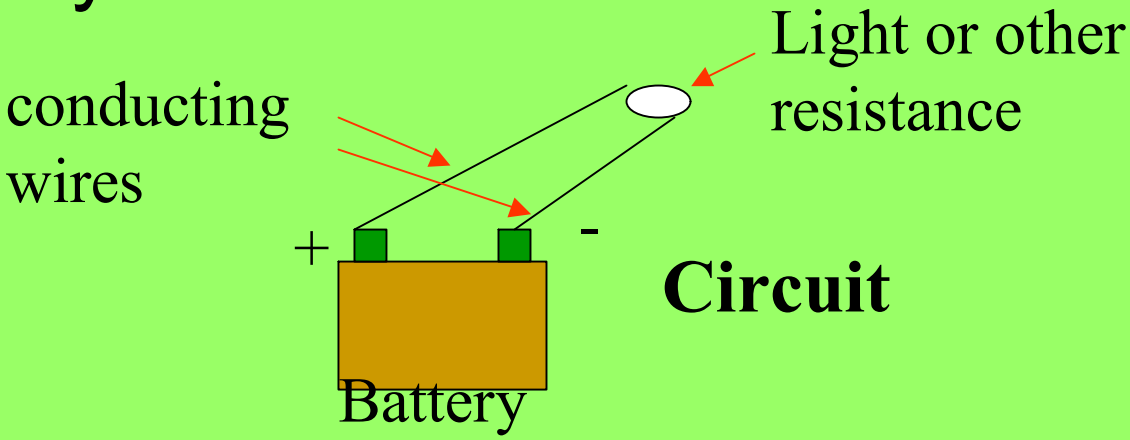
- Force impeding the current. Depends on material and cross section (larger area less resistance). Letter R stands for resistance.
- Measured in Ohms Greek letter Omega, Ω, stands for ohms.

Resistors

- **Resistors:** Special devices which allow current, but resist its flow through them, usually by a known amount.
- Total resistance of a device depends the type of material, its cross sectional area and its length. Bigger area less R, longer length, more R.

Electrical Circuit

- **Circuit:** Closed path of a conducting material allowing a current to flow through it. For example wires flowing to and from a resistor and to and from the battery.



Ohm's Law

- **<u>Ohms Law: I = V/R</u>**
- **The current flowing through a circuit depends on the voltage divided by the resistance.**

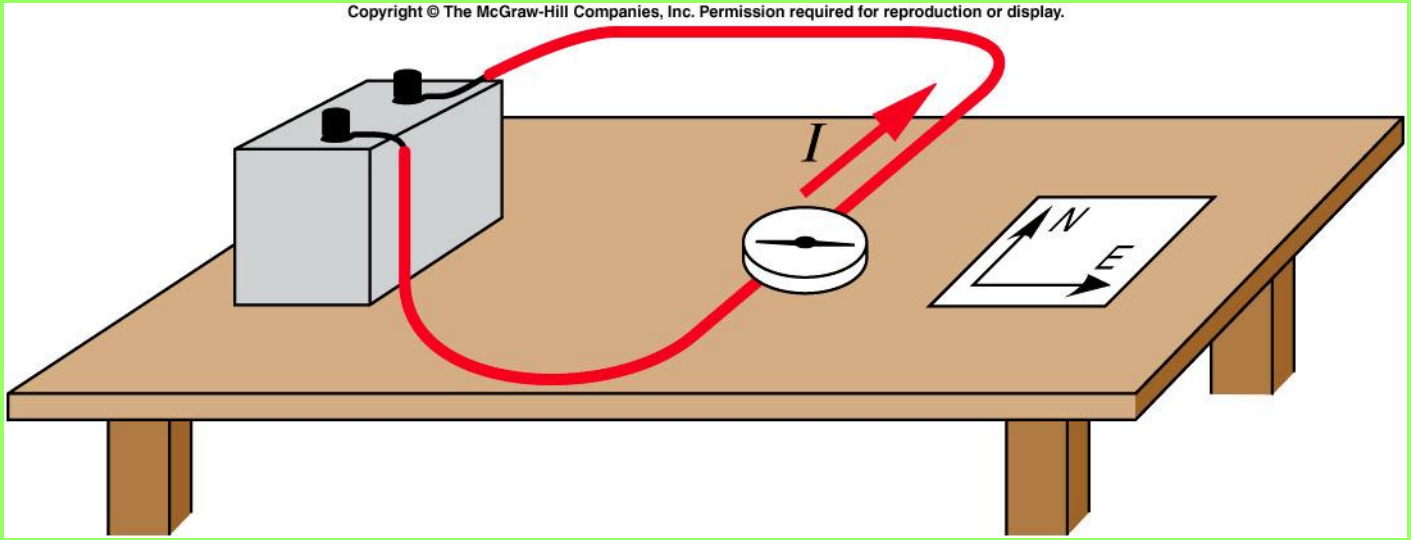
Sample I = V/R Problems

- 12 Volts across/through 10 ohms = 12/10 or 1.2 amps current.
- 12 Volts across 1 ohm = 12/1 = 12 amp
- 12 Volts across .1 ohm = 12/.1 = 120 amps!!! This would burn up most things.
- 12/0 = Infinity! Beware of short circuits (0 resistance). 0 Resistance = infinite current!

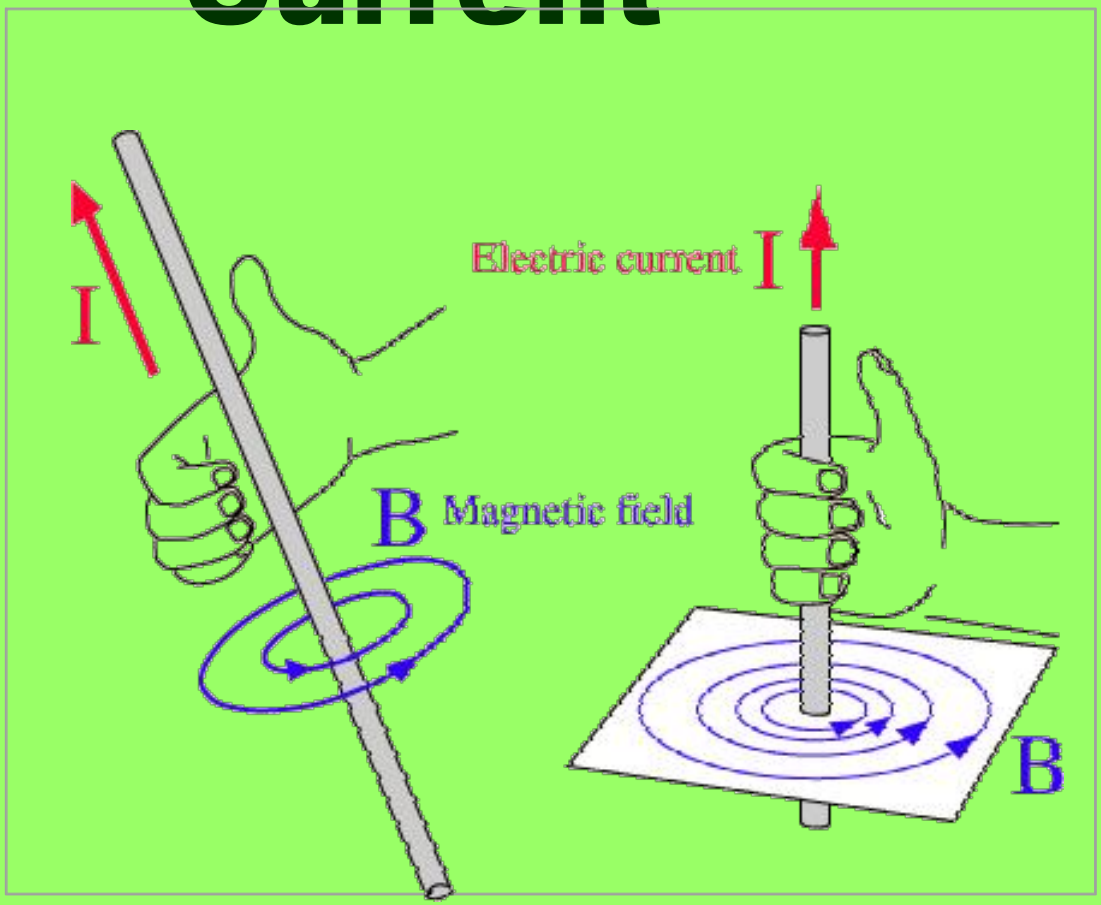
Magnetic Force

- Moving charged particles cause a type of force called magnetic force.
- Magnets create the same type of force

Currents create magnetic fields.



Magnetic Field from A Current



Superconductivity

- Some substances at very low temperatures have no resistance to current.
- Once a current is started in these substances the current would flow forever as long as the temperature stays low.

AC vs DC, Alternating vs Direct Current

- Direct current is current in one direction only.
- Alternating current is current going back and forth, first in one direction then in the other.

Ground

- **Ground** A wire or other conductor leading directly to the earth.
- Your appliances should be grounded to avoid possible shock.

Voltages

- Danger with High Voltages….
- 110 vs 220 varies with country and here with use.
- Even 110 VAC is potentially deadly, depending on your resistance.. i.e. are you grounded?
- Usually 12 Volts no problem for you, but it is for shorted parts!

Frequency of Voltage

- **Frequency of voltage:** The rate at which the current and voltage reverse, e.g. number of phases per second.
- Common AC voltages are 50 or 60 hz. If your equipment is meant for 60 hz, it may not perform well at 50 or vice versa.
- Some foreign countries do not use 60hz as they do in the USA.

Power

- **Power** is the work per unit time your device consumes.
- For electrical devices it is usually rated at maximum. You may actually be using less. If you need more you may have a problem.
- Power is measured in watts. This is the same power as P = W/t, but in electricity we calculate it from current and resistance.

Calculating Power

- **Power, is always work/time but in electricity we calculate it from the formula:**
  $P = I^2R$
- Power used or generated is equal to the square of the current times the resistance of the unit.
- Also we can use **$P = V^2/R$**

Power Supplies

- Usually devices plug into 110 volts AC, but many of them require direct current and/or other voltages to work. As a result they contain a thing called a power supply which changes and regulates the electricity your devices need.

Voltage Furnished from Power Supplies

- A power supply can supply only so much power! If you keep expanding the device or if the voltage fluctuates the power supply may not work properly

Power = Heat

- Power = Heat,
- Using more power generates more heat.
- If your device uses a lot of power it will generate a lot of heat, which must be removed or your system will not perform well and may malfunction.

Voltage and Power

- Lower Voltage usually means less power and less heat.
- A 5 volt processor usually generates less heat than a 12 volt one.
- Most electronic devices like computer chips try to use as low a voltage as possible to cut down heat loss.

Removing Heat

- Because of this heat many devices have internal fans to blow the heat out through a vent.
- If this vent is confined or blocked your device may overheat.
- We also need to make sure our wires do not get too hot.

Lightning and Other Surges

- **Surges** are sudden increases or decreases in Voltage and Current. They can blow up or damage electrical equipment of all types.
- **Causes:** Large motors going on, Lightning, Electric Company Transformer/Generator/Power Problems, Interference through wiring & shorts

Solving Power Problems

- Power is not all good!
- Voltage and other variations can occur in your source of power which can create problems

Power Surges

- Power surges are sudden large increases or decreases in voltage.
- Solution to Surges: Surge Suppressor. A surge suppressor keeps the current from increasing or decreasing too rapidly.
- A spike is a very sharp increase, such as caused by lightning!

Loss of Power

- **Uninterruptable Power Supplies…UPS**
- An uninterruptible power supply can not be interrupted, or shut down. Even if the electricity goes off they have batteries or other devices which keeps the electricity flowing. They are essential in areas where the power may go off frequently, or when any interruption of power can cause a problem.

Using UPS's

- When the electricity goes off a UPS usually supplies power from a battery which is then converted to 110 VAC, often the actual device converts it back to DC again!
- For UPS's Bigger battery (amp-hours) give more time.
- Or if you plug fewer devices or lower power devices in the UPS you get more time.

Heat Problems in Wiring.

- ✸Extension Cords or other Overpowered circuits can cause fires or other problems.
- Current through wires creates heat.
- If you have too small a wire it has a large resistance and creates a lot of heat. If one wire is near or on top of another the heat can buildup and cause the insulation on the wire to burn, or cause a fire in other materials nearby with low kindling temperatures.

Do Not Overload Wires or Circuits

- Make sure you do not overload your circuits or cords. They usually come with a rating. If you do not know what it is, feel them a few minutes after the current is flowing. If they are hot get one with a bigger capacity (larger wires).

Other Electrical Problems

- Interference
  - Frequently coiled wires create magnetic fields which can interfere with delicate instruments. Some machines also create electromagnetic waves which can interfere.
- If you have problems analyze the time and location of the problem, investigate the possible sources.

Possible Problems

- AC Equipment,
- Radio Equipment,
- Electronic Equipment not grounded or shielded by metal cases, or with open cases.

Measuring Voltage, Current & Power

- **Wires in circuits should be marked to help you determine which goes where. The** Positive lead should be red**, and** negative is black**:**
- **Digital meters read negatives, not analogue ones**

Meters

- **Voltmeters** measure voltage, don't mix AC with DC ranges! Always set on the largest range first.
- **Ohmmeters** measure resistance, power must be off!!!
- **Wattmeters** measure power in watts, power must be on or off depending on the type.
- **Ammeters** measure current in amps, power must be on

Multimeters

- **Multi-Meters** meters which measure all or most of the above.
- **Recording Voltmeters** make a recording of the voltage over time, great for long term fluctuations.

Navigation Back To Web

- Raymerry Home
- Back to Classes
- Back to Physics