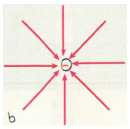
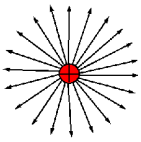
Current, Voltage, & Resistance & Ohms Law

Mr. Sudbury

Electric Fields

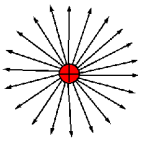
- The space around every electric charge is called an ***electric field.***
- Electric fields have both ***magnitude*** and ***direction.***
- The lines of an electric field show the *direction of a force on a positive charge.*

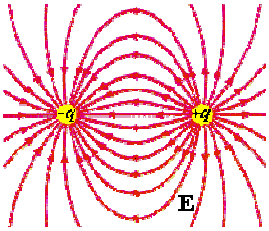


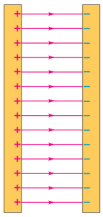


Electric Field Lines

- ***AKA Lines of Force***

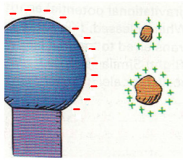


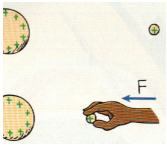




Electrical Potential Energy

- ***Electrical Potential Energy*** is the energy a charged object has due to its location in an electric field.





Electrical Potential

- The electrical potential energy per unit of charge is the electric potential.

$$\text{electric potential} = \frac{\text{electrical potential energy}}{\text{charge}}$$

- The SI unit of measurement of electric potential is the ***volt*** (V). AKA voltage.

The Movement of Charge

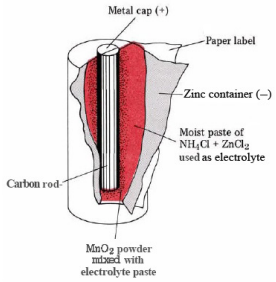
- *Charges can move because an electrical force pushes them.*
- Remember: *Conductors carry the charge.*
- Charges flow through a conductor only when there is a ***potential difference***, or difference in ***voltage***, between the ends of a conductor.
- The flow of charge will continue until both ends of the conductor reach the same potential (voltage).

Voltage Sources

- ***Voltage is the push!***
- Voltage sources provide a continuous "*electric pump*" for the flow of electric charge.
- Voltage Sources:
  - Dry Cells
  - Wet Cells
  - Generators

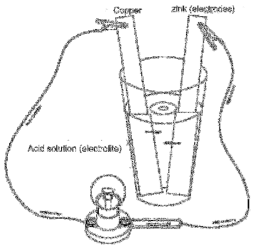
Dry Cell

- Battery



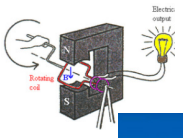
Wet Cell

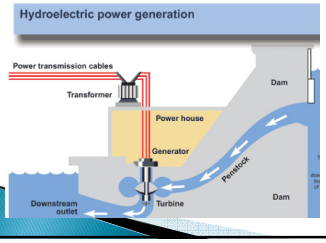
- Car battery



Generator

- Turning a coil of wire in a magnetic field creates electric current.

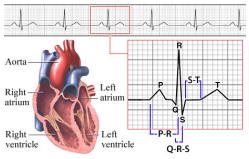




Other Voltage Uses

- AED to shock your heart.

- EKGs are used to record voltage as your heart beats



The Flow of Charge

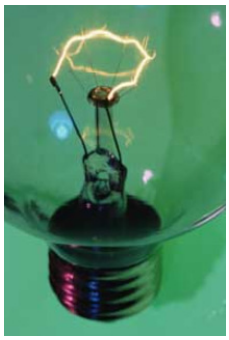
- ***Electric current*** is the flow of charge.
- Measured in amperes (A) or amps.
  - Current can also be described as the rate at which charge passes a given point.
  - 1 ampere is the flow of 1 Coulomb of charge per second.
- Electric current does not flow unless there is a potential difference (voltage).

Electrical Resistance

- The ***resistance*** of a material is the opposition to the flow of charge (aka *current*); measured in ohms (Ω).
- Resistance in a wire depends on:
  1. Conductivity of the material (how well it conducts)
  2. Thickness (width) of wire
     - Thick wires have less resistance then thin wires
  3. Length of wire
     - Longer wires have more resistance than shorter wires
  4. Temperature
     - Increased temperature = increased resistance.

Resistance

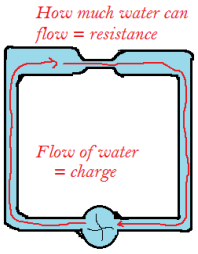
- In many instances, resistance is when electricity (voltage and charge) is turned into another form of energy.



Voltage, Current, & Resistance

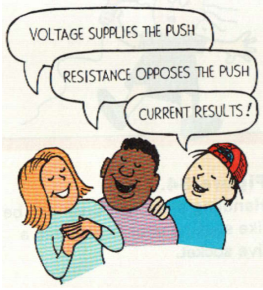
Analogy – Water pipes

- ***Voltage*** is the *push*.
- ***Current*** is the *flow*.
- ***Resistance*** is the opposition to the flow of charge.



water pump = Voltage or "push"

Voltage, Current, & Resistance



Ohm's Law

- Ohm discovered that the

"current in a circuit is directly proportional to the voltage across the circuit, and inversely proportional to the resistance of the circuit."

George Ohm
Germany
1789–1854

$$\text{Current} = \frac{\text{Voltage}}{\text{Resistance}} \qquad I = \frac{V}{R}$$

Ohm's Law Rearranged

$$I = \frac{V}{R} \qquad V = IR \qquad R = \frac{V}{I}$$

Ohm's Law Practice

- How much current is drawn by a lamp that has a resistance of 100 Ω when 50-Volts is passed through it?

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

- What is the resistance of an electric frying pan that draws 12 Amps of current when connected to a 120-v circuit?

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

Ohm's Law Practice

- What is the voltage going to an oven that draws 5 amps of current and has 48 Ohms of resistance?

$$V = IR$$

Electric Shock

- The damage from electric shock is from current that passes through your body.

Various Effects of Current on the Body	
Current (Amps)	**Effect**
0.001	Can be felt
0.005	Painful
0.01	Involuntary muscle contractions (spasms)
0.015	Loss of muscle control
0.07	Possibly fatal if lasts for more than 1 second

Electric Shock

- Dry skin resistance = up to ~50,000 Ω
  - If the resistance of your body were 50,000 Ω dry, what would be the current in your body when you touched the terminals of a 12-volt battery?

$$I = \frac{V}{R} = \frac{12\text{-volts}}{50{,}000\ \text{Ohms}} = 0.00024\ \text{Amps}$$

- Wet skin resistance (salt water) = as low as ~200 Ω
  - If your skin were very moist so that your resistance was only 200-Ohms, and you touch the terminal of a 12-volt battery, how much current would you draw?

$$I = \frac{V}{R} = \frac{12\text{-volts}}{200\ \text{Ohms}} = 0.06\ \text{Amps}$$

Questions

- How does a bird perch on a bare power line and not get shocked?
- There is no potential difference between his feet.

- Why is it dangerous to operate anything electrical while wet?
- Your resistance is lower so there is more potential for a higher current to flow through you.

The End

- Voltage (V) – The push
- Current (I) – The flow
- Resistance (Ω) – resists flow or transfers to another type of energy.