Electric Current

Flow of Charge

- When the ends of an electric conductor have different potentials (voltage), charge will flow.
- The charge will flow until both ends reach the same potential.
- If there is no potential difference, there is no flow of charge.
- Would the flow of charge from a Van de Graaff to the ground be long?
- To sustain a flow, there must constantly be a potential difference.

Electric Current

- Current is the flow of charge.
- The unit for current is Amperes (A)
- An ampere is the flow of 1C of charge per second. (6.24×10^{18} electrons)
- A current carrying object has no net electric charge.
- The amount of electrons entering one end equals the amount of electrons leaving the other end of the wire.

Voltage Sources

- A current needs an electric “pump” to supply electrons.
- The provider is called a voltage source.
- You can use dry cell batteries, wet cell batteries, or a generator to provide a constant supply of electrons to a wire.
- The electrons are provided at the terminals.
- The potential energy per electron moving between the terminals is the voltage or electromotive force (emf).
- The voltage provides “electric pressure”.
- Through vs. across?

Voltage and Current Calculations

- $I = \Delta q / \Delta t$
- I = current in Amperes
- q = charge in Coulombs
- t = time in seconds

Electric Resistance

- A conductor can resist charge flow.
- The resistance is based on four things:
  - the material making up the conductor (how well do the atoms hold their electrons.)
  - The length of the wire (longer wires create more resistance)
  - The cross sectional area of the wire (bigger areas mean less resistance.)
  - Temperature of the wire (higher temp, higher resistance ,remember, higher temp = higher kinetic energy)

Ohm's Law

- Resistance, current, and voltage are related by Ohm's Law
- V=IR
- V=voltage in Volts
- I= current in Amperes
- R = resistance in Ohms (Ω) (1V/1A)
- Electric cords have low resistance (less than 1 ohm.)
- Lightbulbs have a large resistance (140 Ω) More resistance means more energy lost from the same current. Energy lost as heat and light.

Electric Shock

- Current does the damage when shocked.
- Now you can see that current running through your body can be affected by resistance.
- If you are soaked in salt water your resistance would be 100Ω. Dry you would have a resistance of $5x10^5$Ω.
- If dry, 24 volts won't do anything, but if you are wet, it could be harmful.
- What would happen if you touched an outlet dry and wearing sneakers vs. wet while standing in bath water. (Don't try at home)

Current effects

- 0.001A = can be felt
- 0.005A = painful
- 0.010 = muscle spasms
- 0.015 = loss of muscle control
- 0.070 = serious heart disruption if across chest. Possible death if current lasts more than 1 second.

Electrocution anyone?

- Remember, in order to get a shock, you need a potential difference between surfaces. (Bird on a wire)
- Lower resistance, greater current, more dangerous shock.
- Tap water contains Ions that lower resistance and increase current.
- In addition, pipes in the house are grounded.
- That's why water is so dangerous.
- Ground wire in appliances (3rd prong) provides the current with an easier path rather than passing through you.

DC vs. AC

- DC means direct current.
- AC mean alternating current.
- DC refers to current always flowing in one direction.
- Batteries are DC because current always flows from the negative terminal to the positive terminal.
- AC means the current moves first in one direction and then in the other.
- This is done by alternating polarity of voltage at the generator.

Household Voltage

- The original lightbulbs would burn out with high voltages, so the voltage was set at 120V.
- Europe uses 240V for all wiring.
- All current in houses is AC. AC is easy to set up and loses less heat in transfer.
- US uses 3-wire into the house, one +120V, one neutral, and one at -120V. The current alternates between the 2 voltages so there is only 120V potential at a time.
- You only wire with one of the “hot” wires and the neutral unless you wire an appliance.

AC DC Converters

- If you plug in a calculator or cell phone that uses a battery into a wall outlet, you need to convert the AC from the wall into DC for operation.
- This requires a transformer (to lower voltage) and a diode.
- Diodes allow current to only flow in one direction creating DC flow regardless of type of current entering.
- This means its off half the time, and a capacitor is used to smooth out the flow.

Speed of Current

- Electrons normally move very fast within a wire, but since the motion is random, no current is generated.
- When an electric field is present, the electrons motion is not entirely random, it is pushed a little in the direction of the field.
- The wire acts as a guide and the field follows the path of the wire.
- As they are carried along, electrons bump into the metal ions and transfer energy. That's why wire gets hot.
- This bumping interferes with the electrons causing a drift speed or net speed to be low.

Speed of Current cont.

- The normal drift speed is about 0.01cm/s.
- It would take 3 hours for an electron to travel through 1m of wire.
- In AC circuits the electrons drift in one direction, and then back in the other and there is no progress made in either direction.
- The pattern of the motion, or the field, is what is transferred through the wire and sends the signal. The electrons don't move so much.
- That's why the lightbulb goes on immediately.
- Electrons are supplied by the conductor, energy (in the electric field), is supplied by the outlet.

Capacitance

- Remember that a capacitor stores charge on conductors separated by an insulator.
- Capacitance is the amount of charge vs. the potential difference.
- $C=\Delta q/V$
- Unit for C is F (Farad) and is equal to C/V

Electric Power

- The rate at which electrical energy is converted to another form such as heat or mechanical energy is electric power.
- It is equal to W/t. $W=\Delta qV$, sooo $P=IV$
- $I=C/s$, and $V=J/C$, so $P=J/s$ or Watt!
- For homes it is measured in kilowatt-hours for pricing.