ELECTRICITY

Chapter 17

17A Static Electricity

Identifying Charges

- **Static: caused by stationary electrical charges (electrons = e^-)**
- **Electrons**
  - **Negatively charged particles on the outside of atoms**
  - **Atoms can lose or gain e^- to become ions.**
  - **Friction can cause the e^- to move from one substance to another.**
- **Static charge**
  - **In cool, dry rooms you can pick up an excess of e^- as you walk.**
  - **When you touch the doorknob, the e^- jump off = static charge.**
- **Ions**
  - **Atoms that lose e^- become positively charged.**
  - **Atoms that gain e^- become negatively charged.**
  - **There are only two types of charge, and either can produce electrical forces.**
- **Electrical forces**
  - **Two charged objects have an attraction or repulsion for each other.**
  - **The law of charges relates how these charged objects react to each other.**
- **Law of Charges**
  - **Like charges repel.**
  - **Unlike charges attract.**
  - **If the charged objects are close enough, the attraction can overcome the force of gravity.**

Induction of Charge

- **When a charged object is brought near certain uncharged objects, it will attract them.**
- **Induction occurs when the paths of the electron in the object are shifted.**
- **Electrons are NOT transferred.**
- **Transferring charges**
  - **Substances that easily transfer e^- are conductors.**
  - **Substances that do not easily transfer e^- are insulators.**
  - **Substances that are in between are semiconductors.**
- **Conductors**
  - **Easily lose e^-**
  - **Usually metals**
  - **Low electronegativity**
- **Semiconductors**
  - **Medium-strength hold on e^-**
  - **Metalloids**
  - **Medium electronegativity**
- **Insulators**
  - **Strong hold on e^-**
  - **Nonmetals**
  - **High electronegativity**

Producing Charges

To make an atom negatively charged, e^- must be added.

To make an atom positively charged, e^- must be removed.

You cannot add protons to make an atom positively charged.

Van de Graaff Generator

A belt receives extra e^- from a comb and carries the charge to the sphere at the top.

The sphere attracts the charges and stores them.

Massive accumulations of e^- can be stored in this manner.

Rubbing Materials

If a Lucite (plastic) rod is rubbed with wool, the rod becomes positively charged.

Rubbing a hard rubber rod with wool gives it a negative charge.

The cooler and drier the air, the longer these static charges remain on the object.

Storage Devices

A Leyden jar stores static electricity.

A capacitor is a modern device used to store charges.

In both cases, opposite charges are separated by an insulator.

Using Charges

Copiers are designed to use static charge to reproduce the original.

Electroscopes are devices which can detect charges.

Electrostatic filters on industrial smokestacks precipitate out the particles, removing much of the pollution cheaply.

Lightning

Lightning's cause

The water in the clouds is broken into uneven pieces which are charged.

As these charges separate, enough is accumulated in the clouds to break down the insulating capacity of the air, and lightning is produced.

Types of lightning

1. Forked – the usual
2. Sheet – probably forked lightning seen from a distance
3. Ball – very unusual

Lightning rod

It is simply a metal pole attached to the top of a building.

A wire attached to the pole carries the e^- to the ground if it is hit by lightning. (That's why it is called a "ground" wire.)

17B Current Electricity

Identifying Current

Not a "current event" as in history, but a stream of e^- which run on a path.

We call this path a circuit.

When the e^- flow through the circuit, a current is produced.

Battery

A storage area for e^-

They flow out of the negative end (pole) of the battery through the circuit and enter the positive end.

A switch can close or open the circuit, like a drawbridge.

Short Circuit

Like water, e^- will take the easiest path.

When wires touch, the e^- take the shortcut, and a short circuit results.

Causes of Current

Why does water come out of your faucet? Because it is pumped.

A battery pumps e^- out one end.

Electrical potential

When a pump pushes water up a water tower, it stores potential energy.

The e^- at the negative end of the battery are ready to leave and flow through the circuit, like water flows downhill.

This is electrical potential.

Potential difference

As water falls, it loses potential energy (changes to kinetic).

As e^- flow through the circuit, they lose "pressure" and experience a drop in potential; that is a potential difference.

Volts

Potential difference is measured in volts (v).

A volt is the push needed to move a certain amount of e^- through a circuit.

Volts are like the pressure needed to move water (p.s.i.).

Coulomb

A large number of electrons: 6.25×10^{18} to be exact

This is 6 quintillion, 250 quadrillion.

Voltage of a circuit

The drop in electrical potential (potential difference) between the two electrodes of a battery

A 6-volt battery (lantern) has more push than a normal 1.5-volt battery cell does.

Amperes (Amps)

A unit to measure the amount of e^- (current) that flows through a wire in a certain amount of time.

This would be like the number of gallons of water that flow through a pipe in a certain amount of time.

Controlling Current

Resistor

A device that resists the flow of electrons.

This would be like a paddle wheel which would absorb some of the energy of water.

Resistance

The ability of a resistor to absorb some of the energy of e^- is called resistance.

Resistance is measured in units called ohms (Ω).

Conductors have low resistance, while insulators have high resistance.

Volts, amps, and ohms

It takes 1 V of "pressure" to push 1 A of current through a resistor which has a resistance of 1 Ω.

It takes 20 V of push to send 5 A of current through a 4-Ω resistor.
How many volts will it take to send 3 A through a 4-Ω resistor?
To find out, use Ohm's law.

Ohm's Law
Potential difference = (current)(resistance)
Volts = (amps)(ohms)
$V = I R$
Sample Problem: If a clock uses 0.1 A of current with a potential difference of 110 V, what is the resistance of the clock?
$V = I R$
$110 = (0.1) R$
$1100\ \Omega = R$

Measuring devices
An ohmmeter is used to check for short circuits and incomplete circuits.
A voltmeter is used to check the "power" left in a battery while in use.
An ammeter measures the amount of current flowing, as when charging a battery.
A multimeter is a combination of an ohmmeter, an ammeter, and a voltmeter in one device.

First Law and e^-
All devices have some resistance: energy is lost from the wire to the device.
Since this energy cannot be destroyed, it must change form to motion (motor), heat (oven), light (bulb), and sound (speaker).

Types of circuits
1. Series
   "Series" means one follows the other.
   In a series circuit, all current must flow through only one path: first through one device, then through another, and so on.
   Since all the e^- must follow one path, if one device is removed, breaking the path, the current will stop.
   Could the receptacles in your house be wired in series?
2. Parallel
   These have more than one path for e^- to follow.
   The current divides between the paths.
   If one bulb burns out, the e^- that would have flowed through that bulb flow through the other paths.
   The remaining lights stay lit, but each one is brighter than before.

Power and Current
Power is how fast energy is used.
Electrical companies do not care how fast you use energy, only how much you use each month.
They measure how many kilowatts you use each hour and bill your family for the total kilowatts used each month.
Kilowatt-hours
If a 1000-watt hair dryer is used for an hour, one kilowatt-hour (kWh) of energy is used.
If a radio uses 10 watts, it would have to operate for 100 hours to use 1 kWh of energy.

Electric companies charge about 6 to 20 cents for each kWh used, and the average family uses around 1000-2000 kWh each month.

Power equation

$P = V I$

Watts = (Volts)(Amps)

Sample Problem: If a 110-V appliance draws 15 amps of current, how many watts of power does it use?

$P = (110)(15)$

$P = 1650$ Watts

Wires and current

Every wire can carry only so much current before it becomes so hot that it could start a fire.

A fuse or circuit breaker is used as the part of the circuit that is weakest so it will stop the flow of e^- before the wire gets too hot.

Light bulbs

How is electricity changed to light?

When electricity passes through the light bulb, it encounters much resistance. This heats up the filament so much that it glows.

Although it gives off the desired light, some energy is also wasted as heat (2nd Law).

Types of lights

1. **Arc lights**
   These were the 1st electric lights.
   They are very bright and harsh, suitable for searchlights, etc.
   A carbon rod is placed between two wires. The electricity "arcs" between the wires through the carbon producing the light.
2. **Incandescent lights**
   These are regular household lights.
   The filament is made of tungsten. It has a high resistance and a very high melting point.
   The gas in the bulb is argon.
3. **Fluorescent lights**
   These are also called "shop" lights; they are long tubes with no filament.
   The mercury gas in the tube glows when the electricity passes through it.
   The light produced is not visible but ultraviolet, so a coating is used to reduce the energy down to the point where it is visible.