**Physics 11**

**Electric Fields**

And Forces

- Atomic Structure
- Conductors / Insulators
- Charging an Object
- Induced Charge
- Lightning

**Electric Fields**

Excess Charge on a Conductor

**Atomic Structure**

- nucleus: consists of protons (+ charge) and neutrons (no charge)
- surrounding the nucleus are electrons (- charge)

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**Important Facts About Atoms**

- electric charge ⇒ that property to which the attractive and repulsive behavior of protons and electrons is attributed

⇒ We do not know what charge is, we only know that there are two types of charge.

⇒ The two types of charge were called positive (+) and negative (-) by Benjamin Franklin in 1747.

- Every atom is composed of a positively charged nucleus surrounded by negatively charged electrons.

⇒ The electrons, of all atoms are identical; they have the same mass and the same charge (also true of protons and neutrons)

⇒ Protons have the same charge as electron (but opposite signs) but have about 1800 times more mass. Neutrons have a little more mass than protons but they have no charge.

⇒ Most atoms are neutral because they have the same amount of protons as electrons.
opposite charges attract

like charges repel

It is relatively easy to strip the outer electrons from a heavy atom like that of uranium but very difficult to remove inner electrons. Why do you suppose this is so?

⇒ For the outer electrons, the attractive force of the nucleus is largely canceled by the repulsive force of the inner electrons. The inner electrons fell the full force of the nucleus, and a large force is required to remove them.

Conductors

⇒ One or more of the outer electrons in a conductor are free to wander within the metal.

ex: copper, aluminum, silver, gold

Insulators

⇒ Electrons are tightly bound to the atoms in an insulator.

ex: plastic, rubber, wood, pure water
Objects can gain or lose electrons by being rubbed together.

**Charging by Friction**

- **Example of charging by friction**
  - Electron are rubbed off of the man’s shoes and onto the rug (charge is conserved).

- **Another example of charging by friction**
  - Electrons are rubbed off the man’s head onto the balloon (charge is conserved).

**Charging by contact**

- Ebonite rod
- Metal sphere
- Insulated stand
**Charging by induction**

- no contact was ever made with the charged object

**Induced charge**

- induced charge: positive and negative charges in the molecules of an insulating material become slightly separated

- The balloon sticks to the wall because the positive charges in the wall (which exert an attractive force) are closer to the balloon than the negative charges in the wall (which exert a repulsive force). Closeness wins!

- Since the negative charges are closer to the (positively) charged comb than the positive charges, the paper feels a net attractive force (closeness wins).
Why objects lose electric charge

⇒ water vapor and other molecules running into a charged object can eventually remove all excess charge from the object

Lightning

⇒ Charging by induction occurs during thunderstorms.

⇒ The negatively charged bottom of clouds induce a positive charge on the Earth’s surface.

⇒ Lightning is the electrical discharge between a cloud and the ground or between oppositely charged parts of clouds.

Lightning (cloud to ground lightning)

⇒ Before lightning strikes, negatively charged stepped leaders come down from the cloud and positively charged upward streamers rush upwards from objects on the ground.
If the negatively charged stepped leader meets a positively charged upward streamer, a path is formed and electrons rush from the cloud to the ground. This is a lightning strike!

In both of these picture, you can see an upward streamer rushing up from the ground.

Most lightning actually occurs between oppositely charged parts of clouds.

Lightning can also strike from the ground up to a cloud.
There have also been reports of ball lightning, which usually appears as a mysterious glowing sphere which drifts horizontally through the air.

 ⇒ we use a small positive test charge to determine the magnitude and direction of an electric field.

Electric fields are represented graphically by using field lines.

1) the closer the field lines, the stronger the field
2) field lines point away from a positive charge and towards a negative charge
3) the # of electric field lines is proportional to the magnitude of the charge
Some Electric Fields

⇒ Excess charge placed on a conductor will move to the surface of the conductor because the electrons mutually repel each other.

⇒ Excess charge will arrange itself on the surface of the conductor such that the electric field inside the conductor is zero.

⇒ It will only be evenly distributed if the conductor is spherical.

⇒ The electric field just outside a conductor is perpendicular to the surface of the conductor (in an electrostatic situation).