# Grade 11 Notes June 8-12, 2020

This week we are starting our last unit on Electromagnetism. It is important that you download the notes for Grade 12 as we will be expecting you to be familiar with the information.

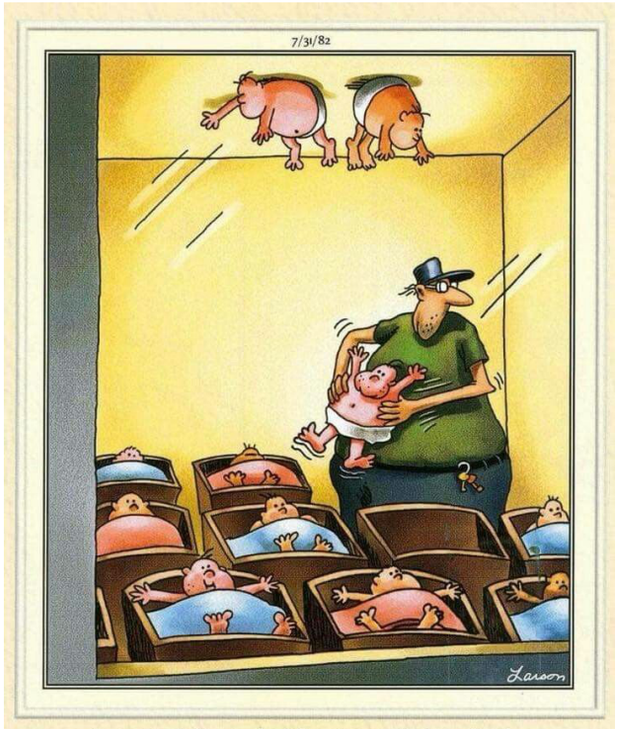
This week we are going to investigate electricity with the following notes

1. **Introduction to Electrostatics**
2. **Methods of Charging and Charge Detection**
3. **Millikan's Oil Drop Experiment**

Remember there is  assignment due this week on Wednesday June 10, 2020.  This was the last note as next week I will be busy doing reports and the next week is the last week of school.  This does not mean you can stop doing work, I will be putting out notes till the last week to finish the course. Still cover the material presented.

Have a good week.

Miss Takken




Late at night, and without permission, Reuben would often enter the nursery and conduct experiments in static electricity.

## 1. Introduction to Static Electricity

History

1. **600-200 BCE Early Greek Scientists** discovered "amber effect". Amber is fossilized tree resin. When rubbed amber will pick up bits of dry straw and lint. You could replicate the amber effect with a balloon. Rub the balloon on your hair and you can pick up tiny pieces of paper or pencil shavings. This is because the balloon gathers electrons from the hair through friction. This gives the balloon an excess of negative charge. The paper is neutral so it is attracted to the negative charge and moves towards the balloon.

   The Greek word for amber is "elektron" so anything that displayed the amber effect became known as electriks or electricity.

   Any object that behaved like amber were said to be electrified or electrically charged. Any materials that would not show the amber effect were said to be neutral.

2. **1400 - 1500 CE Renaissance Period.** Renaissance means "rebirth". It was the time of advancement in arts, science and technology. During this time the study of electricity continues. It was discovered that some materials **attract** while other **repulse** depending on the material used. This is known, now, as electron affinity. Electron affinity is the property of matter that describes how well it gives up/or accepts electrons. If it gives them up it will become develop a positive charge and if it accepts them it will become a negative charge.

**Electron Affinity** is the tendency of a substance to hold on to electrons.

**A Triboelectric Series ~ order of electron affinity**
(Tribos = Greek for "to rub")

Tends to lose electrons (becomes positively charged)

human hands
(dry)
glass
human hair
nylon
cat fur
silk
cotton
steel
wood
amber
ebonite
plastic wrap
teflon

* the order is even specific to which type of tree the wood comes from or which type of animal the fur comes from.

The list shown is a very small portion of the actual list, which has thousands of substances.

Tends to gain electrons (becomes negatively charged)

So here if human hair is rubbed with silk the human hair will become positive (lose electrons) and the silk will gain electrons (become negative) because it is lower on the list.

3. **<u>Benjamin Franklin (1706-1790)</u>** was a Founding Father of the United States and a polymath, inventor, scientist, printer, politician, freemason and diplomat. Franklin helped to draft the Declaration of Independence and the U.S. Constitution, and he negotiated the 1783 Treaty of Paris ending the Revolutionary War.

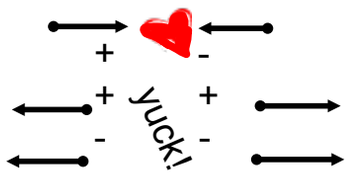
   His scientific pursuits included investigations into electricity, mathematics and mapmaking. A writer known for his wit and wisdom, Franklin also published Poor Richard's Almanack, invented bifocal glasses and organized the first successful American lending library.

   In his study of electricity he stated that there are two types of charges **Positive and Negative** and that all objects possess electricity. He said that a positive charge equals adding electricity, a negative charge equals removing electricity, and anything neutral equals a normal amount of electricity. **This is so wrong!**

   He was correct in stating that there were positive and negative charges but he didn't know what caused those charges (electron wasn't discovered until J.J. Thomson from our chemistry). Now we know that a positive charge is actually removing electrons, a negative charge is gaining electrons and a neutral charge is a balance between positive and negative.

Now what Ben was correct on was the **<u>Fundamental Law of Electric Charges</u>** which state

1. <u>Opposite</u> electric charges <u>attract</u> each other.
2. <u>Similar</u> (like) electric charges <u>repel</u> each other.
3. Charged objects attract some neutral objects.




Note: Neutrals attract/repel nothing. They only move towards charges.

**<u>Atomic Theory of Matter</u>** today this is our understanding of particles and what makes up charges.

1. All matter is made up of  particles called atoms.
2. Electric charges within the atom are carried by electrons and protons.
3. Protons are found in the centre of the atom called the nucleus. They are small but heavy relative to electrons and positively charged.
4. Electrons orbit the nucleus and are approximately 1/2000 th the mass of a proton. However, the charge is equal but opposite to that of a proton.  They are  negatively charged.
5. Normally atoms are neutrally charged.  # of electrons = # of protons
6. Neutrons are found in the nucleus.  A little heavier than protons. Mass 1 neutron = mass of 1 proton + mass of 1 electron.
7. Negative ions have "extra" electrons, negative charge.
8. Positive ions have "less" electrons than protons, positive charge.

Rule:  **All electric charges in solids are due to an excess or deficit of electrons.**

**<u>Static Electricity</u>** is electric charge that builds up on the surface of an object. Static electric charge remains in one location until a path for escape is given.  Watch the following videos for some static electricity demonstrations.

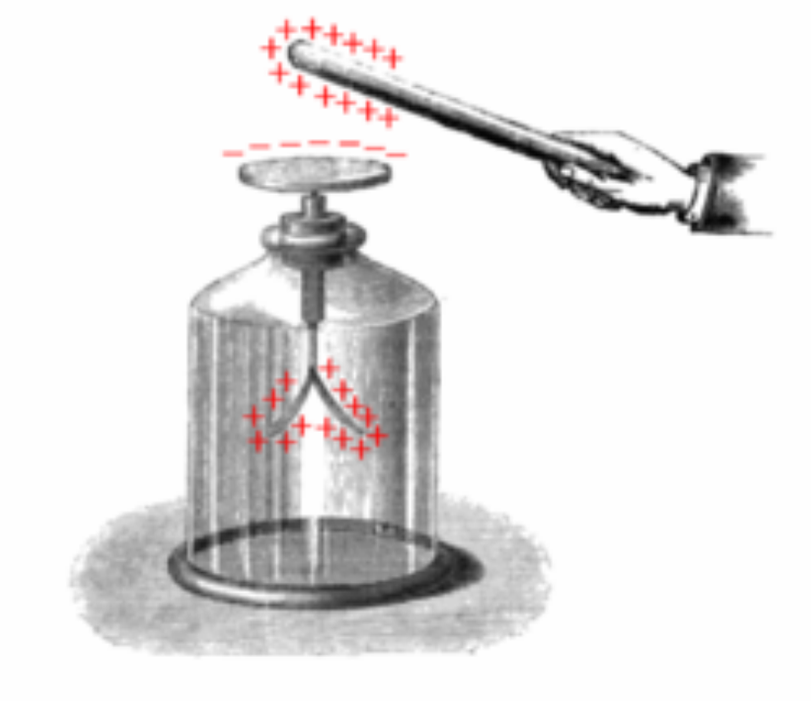
https://www.youtube.com/watch?v=ViZNgU-Yt-Y https://www.youtube.com/watch?v=ubZuSZYVBng

**<u>Conductor</u>** ~ any solid which electrons are able to move about easily.  i.e. most metals (copper, silver, aluminum)

**<u>Insulator</u>** ~ any solid in which electrons are unable to move easily.  i.e. plastic, ceramics, cork, glass, wood, rubber.

## 2. Methods of Charging and Charge Detection

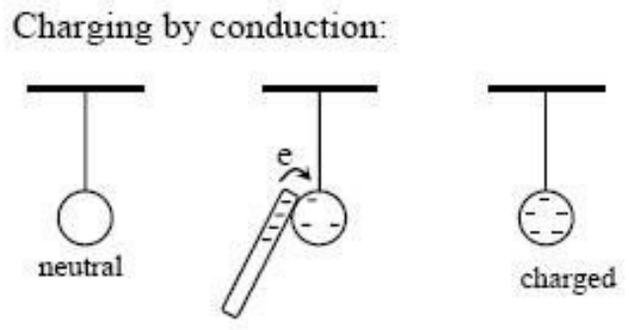
A gold leaf electroscope contains a metal rod with a thin leaf of gold (or other light weight metal) at the base and a cap at the top. When an electrically charged object is brought close to the cap it makes the leaf move away from the rod. The charge makes the electrons move up or down the rod. [Positive = up, negative = down]. The leaf and rod each gain the same kind of charge, so the rod repels the leaf. This contraption can detect charge, but not if it is positive or negative. So how can we introduce a charge to an object.



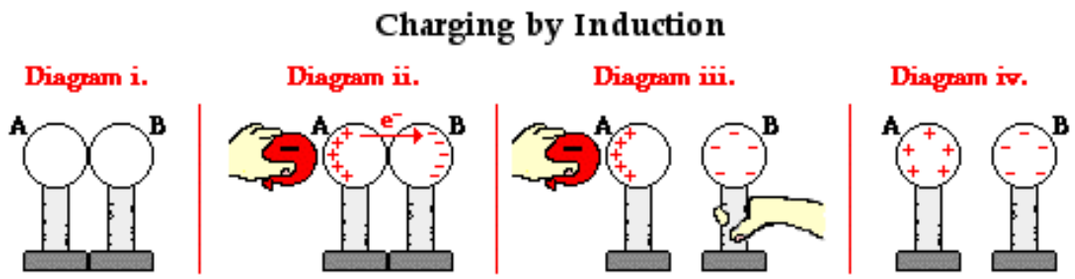
## Methods of Charging an Object

1. **By friction** ~ one object gains electrons while its partner loses them.
   the friction increases the energy of the electrons.

2. **By Contact** ~ an object charged by contact has the same sign as the charging rod. Here one charged object touches another object and gives aways half of its charge.



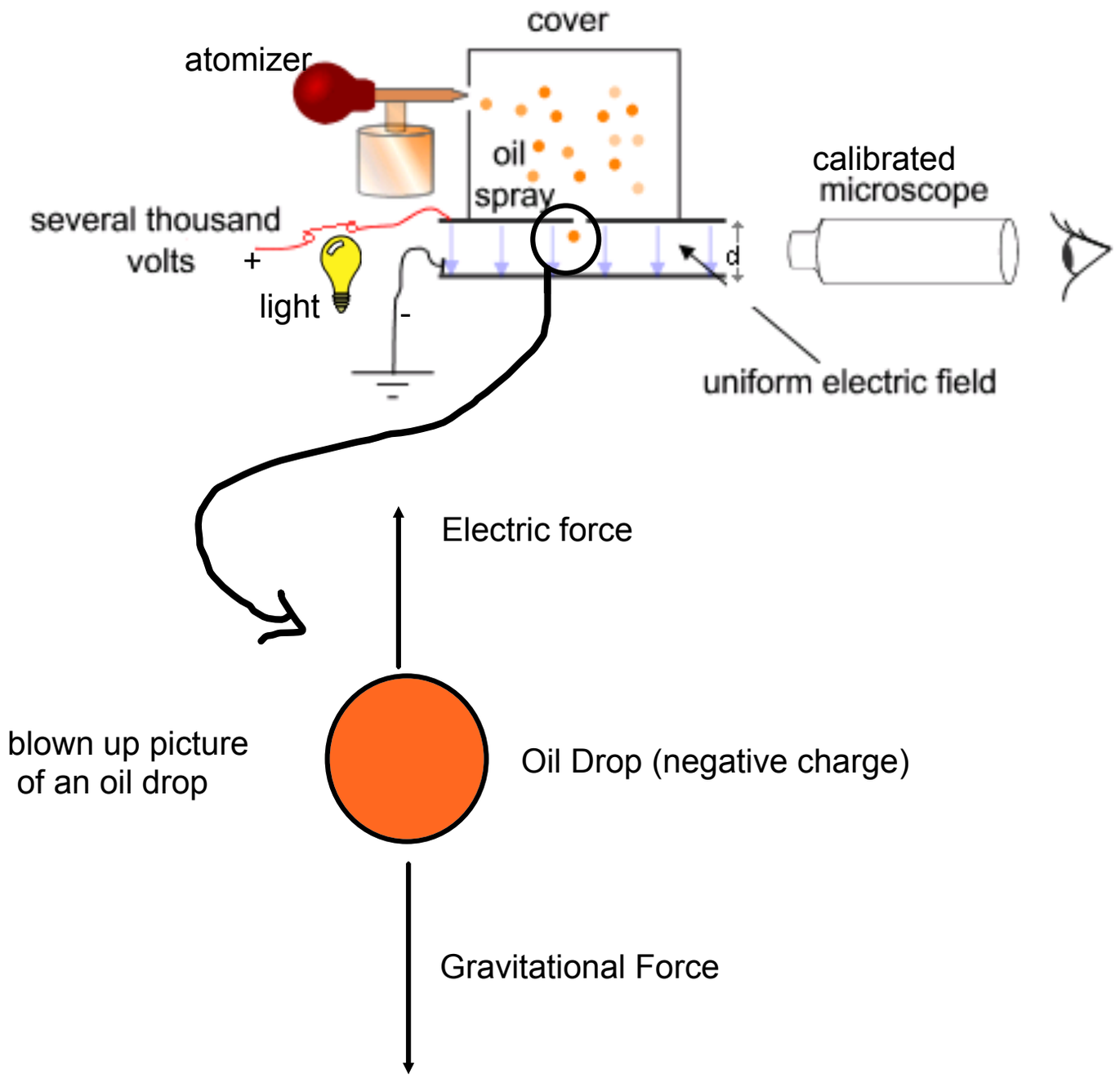

3. **By Induction** ~ an object that is charged by induction has the opposite charge as the inducing object. Here an object is brought close, but not touching another object. The same charge is repelled leaving the opposite charge present.



### 3. Millikan's Oil Drop Experiment (one of the beautiful experiments of physics)

Robert Millikan (1868-1953) proved that there is a unit of electric charge of which all other charges are multiples. He speculated that the lowest possible charge would be that of a single electron. He was right.

**The Experiment ~ Millikan's Apparatus**



1. Oil Drops are sprayed from an atomizer and are charged by friction. Some gain electrons (negative) while some lose electrons (positive).

2. Oil drops fall between parallel plates and are observed with a telescope.

3. Battery is connected between the plates of the capacitor creating an electric field.

4. By adjusting the electric potential difference (voltage, V), one drop is isolated.

5. When the drop is balanced the gravitational force exerted downward upon it is equal to the electrical force acting upward.

$$F_e = F_g$$
$$q\varepsilon = mg$$
$$q(V/d) = mg$$
$$\boxed{q = mgd/V}$$

~ the charge needed to balance the oil drop

where V is voltage on the plates and d is the separation, m is the mass and q is the charge.

6. Procedure is repeated many times with various oil drops.

7. Analyze the data and look for the smallest common factor.

Results: Millikan did this experiment many times. He analyzed this data with cautious optimism and ...

a. Found the smallest charge to be **e = 1.602 x $10^{-19}$ C** (coulomb's)
b. All other charges are the whole multiples of this charge governed by the equation q = Ne

This careful analysis paid off because Millikan won the Nobel Prize in 1923. From this we can calculate the value of any charge and know how many electrons make up this charge.

Conclusion:

$e = 1.602 \times 10^{-19}$ C

(Fundamental unit of charge and charge on one electron)

$1\ C = 6.24 \times 10^{18} e$

Any object with an excess or deficit of N electrons has a charge q where

$q = Ne$ where q = total charge in any given object
N = number of electrons
e = charge of one electron

Example: Riley has an excess of $1 \times 10^{8}$ electrons on him, what is his charge?

$q = Ne$
$q = (1 \times 10^{8})(1.602 \times 10^{-19})$
$q = 1.602 \times 10^{-11}$ C