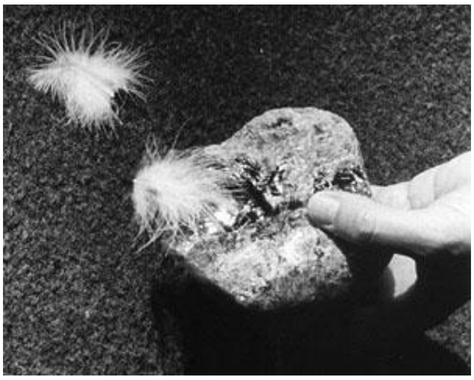
Chapter 1 Static Electricity

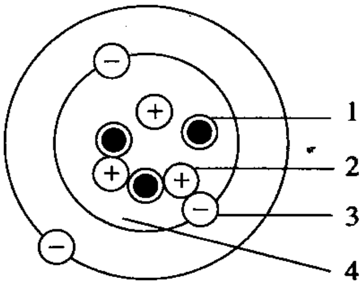


- First Experiment by Thales of Miletus (625-547 BC).
- Electric charge settle on the fixed position is static electricity.
- Electric charge is moving around → dynamic electricity.

  - Rub amber with wool.
  - Amber becomes negatively charged by attracting negative charges (electrons) from the wool.
  - The wool becomes positively charged.
  - The amber can then pick up a feather.
  - How?

1.1 Electric Charge

Electric Charge Properties



Parts of Atom

Matter has many atoms. Atom is the smallest substance of element. Elements are made up of tiny particles called atoms. Every element is consist only one atom. Each element has its own type of atom.

Atom has sub-atomic particle: Proton, Neutron, and Electron

1. Neutron (no electric charged)
2. Proton (positive charge)
3. Electron (negative charge)
4. Nucleus (Neutron + Proton)

Electric charge can be named as a wind. It is can't be touched but the effect can be felt.

In the dry weather → the effect of electric charge can be seen.

Materials can be charged by rubbing:

For example: plastic is rubbed by wool, plastic will become negative charge. When plastic brought it closer to the pieces of paper, the paper will be attracted by plastic.

How materials can be charged by rubbing?

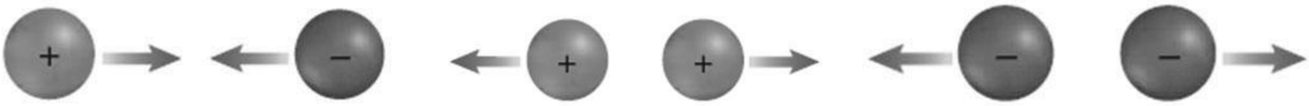
- Neutral atom: Σ proton = Σ electron
- Proton is very hard to move but Electron is easy to move.
- Rubbing → giving energy → to move electron from one place to the other place.
- Σ electron > Σ proton → Negative charge
- Σ electron < Σ proton → Positive charge

Materials can be charged by conduction.

- Only for conductor materials
- Electron can move easily through the conductor materials.
- Contact directly
- Almost of metals are conductors

Conductor		Insulator
Good	Poor	
Any metals: silver, copper, aluminum.	Water, human body, soil.	Rubber, any plastics: PVC, politen
➢ Electrons are able to move easily through the materials ➢ Can be given electric charge by friction or rubbing but at the end of the rood must be given insulator materials. ➢ Impact: Electrons are not able to move to the ground because insulator rood. ➢ For Ex: insulated wires in household electrical cable have the function to avoid electricity shock.		➢ Electrons are very hard to move through the materials ➢ Can't transfer the electric charges ➢ Electric charges can be transferred by friction or rubbing. ➢ Plastic + Wool → Electrons are moved from wool to plastic → Σ electrons on the plastic will increase → plastic has negative charge.

Electric Charge Properties



Attract Repulsion Repulsion

Coulomb's Law

- Force between two charges: Attract Force or Repel Force
- Can be formulated into mathematical analysis by Charles Augustin de Coulomb.
- Physical Quantities: the amount of charge (Q) and distance between of charges (d).
- Electric force (F) (repulsion or attraction) between two of charges is proportional to the each of the charges and inversely proportional to the distance square between of them
-

$$F_C = k\frac{q_1 q_2}{r^2}$$

Force…..(F_c) in Newton
q_1 and q_2 are charges and measured in coulombs (C)
r is distance between two of charges…….meter (m)
k is the coulomb constant……. $k = 9 \times 10^{9}$ N m^2 C^{-2}

$k = \dfrac{1}{4\pi\varepsilon_0}$ with $\varepsilon_0 = 8.85 \times 10^{-12}$ N^{-1} m^{-2} C^2 is called permittivity constant

- Charges have the mass for every charge.
  - Mass of proton: 1.67×10^{-27} kg
  - Mass of electron: 9.1×10^{-31} kg
- The form of Coulomb's Law is exactly the same as for Gravitational Force between two masses.

$$F_g = G\frac{m_1 m_2}{r^2}$$

Force…..(F_g) in Newton
m_1 and m_2 are masses and measured in kilogram (kg)
r is distance between two of masses…….meter (m)
G is the gravitational constant……. $G = 6.7 \times 10^{-11}$ N m^2 kg^{-2}

Finding coulomb constant (k) by using linear graph

- Application from equation linear system and linear graph in mathematics ($y = mx + c$)
- Arrange the coulombs equation into linear system; assume that q_1 and q_2 have known.
- The equation will become:

$$F_C = kq_1q_2\frac{1}{r^2}$$

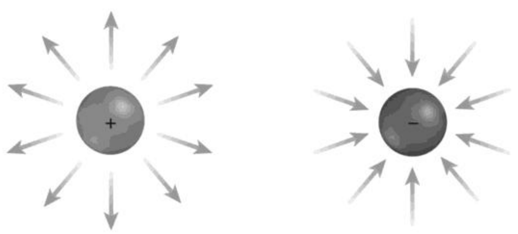
$F_c \rightarrow y$ axis
$kq_1q_2 \rightarrow$ gradient in linear graph
$\frac{1}{r^2} \rightarrow x$ axis

- For kq_1q_2 is equal with the gradient (m) so the equation will become

$$k = \frac{m}{q_1 q_2}$$

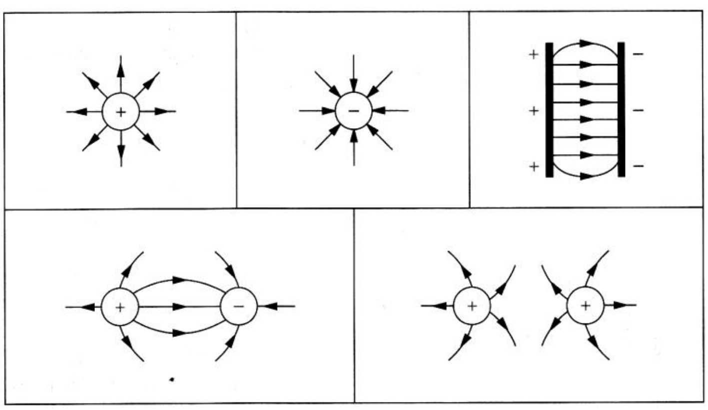
- Arrange the data experiment of coulombs into linear system equation.
- Let's do a lot of exercises for that's all above.

Electric Field



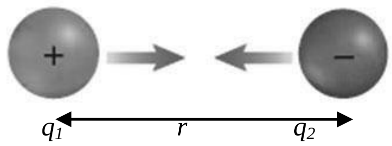
- How do things interact with each other when they don't physically touch?
- Problem has occupied many great minds
- When we talked about gravity, we said that Einstein demonstrated that mass distorts spacetime and the bending of spacetime made objects appear to experience a force
- Can talk about a *gravitational field*
- Place a charged particle in space and time and it creates an *electric field*

- Using Coulomb's Law, we can calculate the force on a test charge at every point in space
- Surrounding every charge is an electric field, through the electric field, a charge is able to push or pull on another charge
- Area around the charges is electric filed
- Electric field can be shown by plotting or drawing electrical force lines.



Representing Electric Field.

- The force per unit of charge is the definition. The formula can be written:



Electric Field Strength at q_1 is $E_{q_1} = \dfrac{F}{q_1} = k\,\dfrac{q_2}{r^2}$ ……….N/C

Electric Field Strength at q_2 is $E_{q_2} = \dfrac{F}{q_2} = k\,\dfrac{q_1}{r^2}$ ……….N/C

Electric Potential

- Potential energy will become kinetic energy when two of charges are separated by distance or between two plates parallel. It is called electric potential.
- Charge in an electric field experiences a force according to Coulomb's Law
- If the charge moves in response to this force, work is done by the electric field
- The potential difference between two points (charge to the charge) in an electric field is the work done per unit charge as the charge is moved between these two points. This physical meaning can be represented by this equation below:

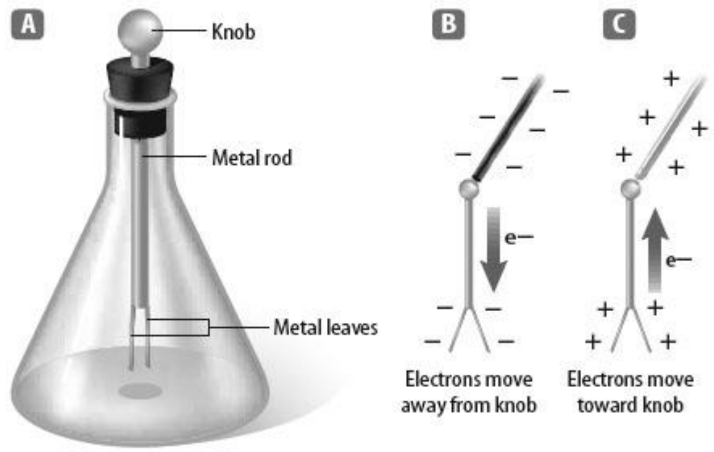
$$\Delta V = \frac{W}{q}$$ ……..Volt or J/C

- Since $V = \dfrac{F \times d}{q}$ and then $\dfrac{V}{d} = \dfrac{F}{q}$, so the equation will be $E = \dfrac{V}{d}$ ……volt/meter as an alternative to measure electric field strength.

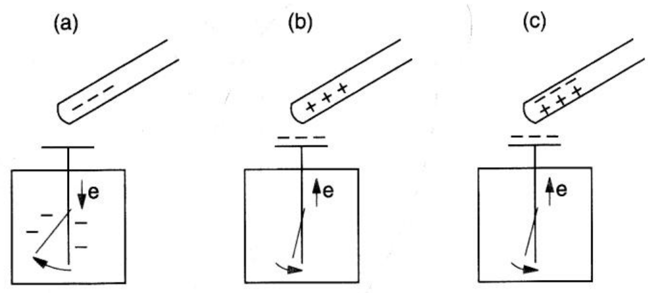
1.2 Electrostatic Induction

Definition:

- Separation of electric charges through the conductor material because the conductor material is brought it closer to the electric charged materials without contacted.
- The production of a charge in an uncharged body by bringing a charged object close to it.
- Electroscope is a device to detect electric charges and to identify the kinds of charges.

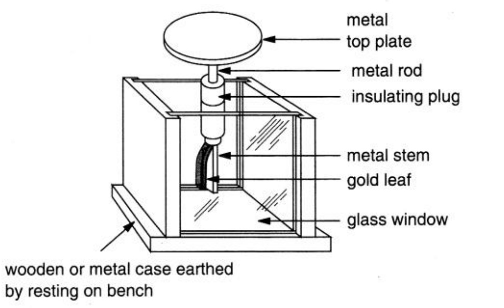


Picture: Simple Electroscope
A: positions of the leaves when they are uncharged.
B: negatively charged
C: positively charged



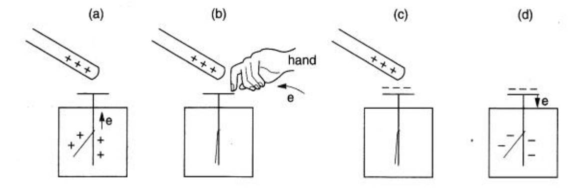
- Bring the charged material closer to the knob without touching the knob.
- It is able to make deflection for the leaves by adding either positive or negative charges
- We seem to be able to make it move without touching it.

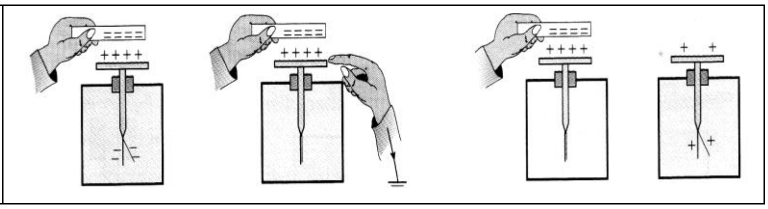
Electroscope Charging by Induction:



Picture: Electroscope

- Plastic (negatively charged) is brought it closer to the knob of electroscope
- Touch the knob by using finger
- Electron will flow to the earth (grounding/earthing)
- Remove the finger and remove the plastic
- Electroscope will become positively charged.
- It will be same thing if it will be used for Glass rood (positively charged). Please think about it.





Detecting and Testing for the sign of charge:

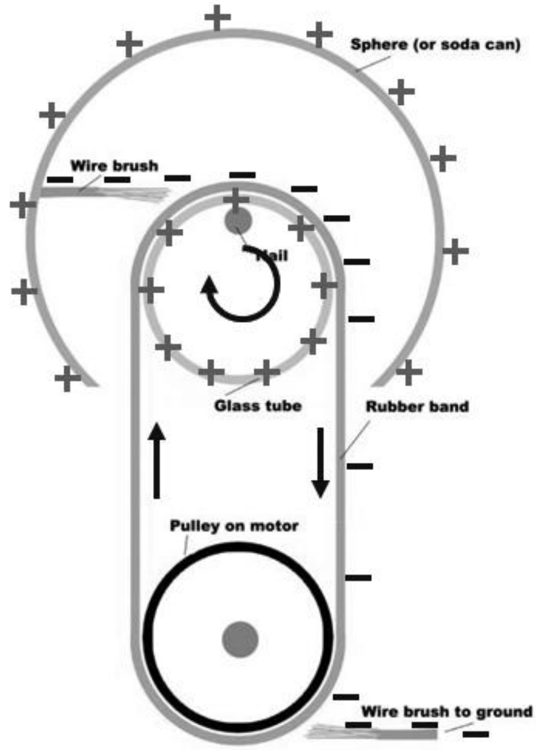
- ∆ It is impossible to define the sign of charge by using neutral electroscope.
- ∆ Electroscope has to be charged before used it.

1.3 Electric Charges Distribution

Electric Charges Distribution through the Conductor Materials

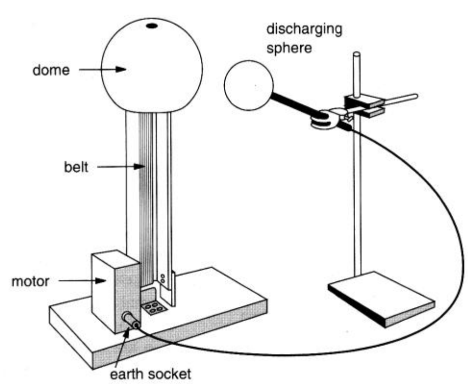
- ❖ Electrons are able to move through conductor
- ❖ Electrons are only distributed up on the surface of body and are not inside the body.

Van de Graff Generator

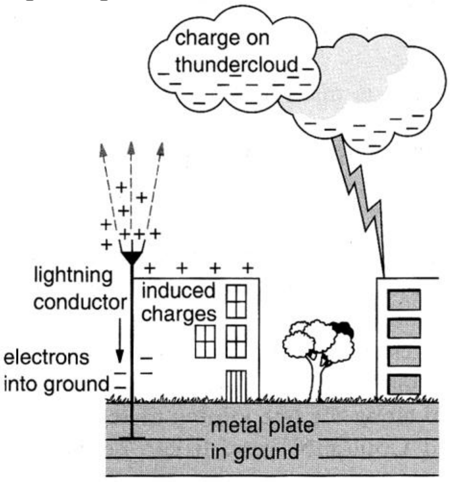


- o Produces a large and continuous supply of electric charge
- o A rubber belt rubs against a plastic roller and becomes charged
- o The charge is carried by the moving belt up to the metal dome, where it is collected
- o A large quantity of charged therefore builds up on the dome
- o Wool, metal sphere, micro ammeter will show electrons flow.

Electric Charges



Lightning Conductor



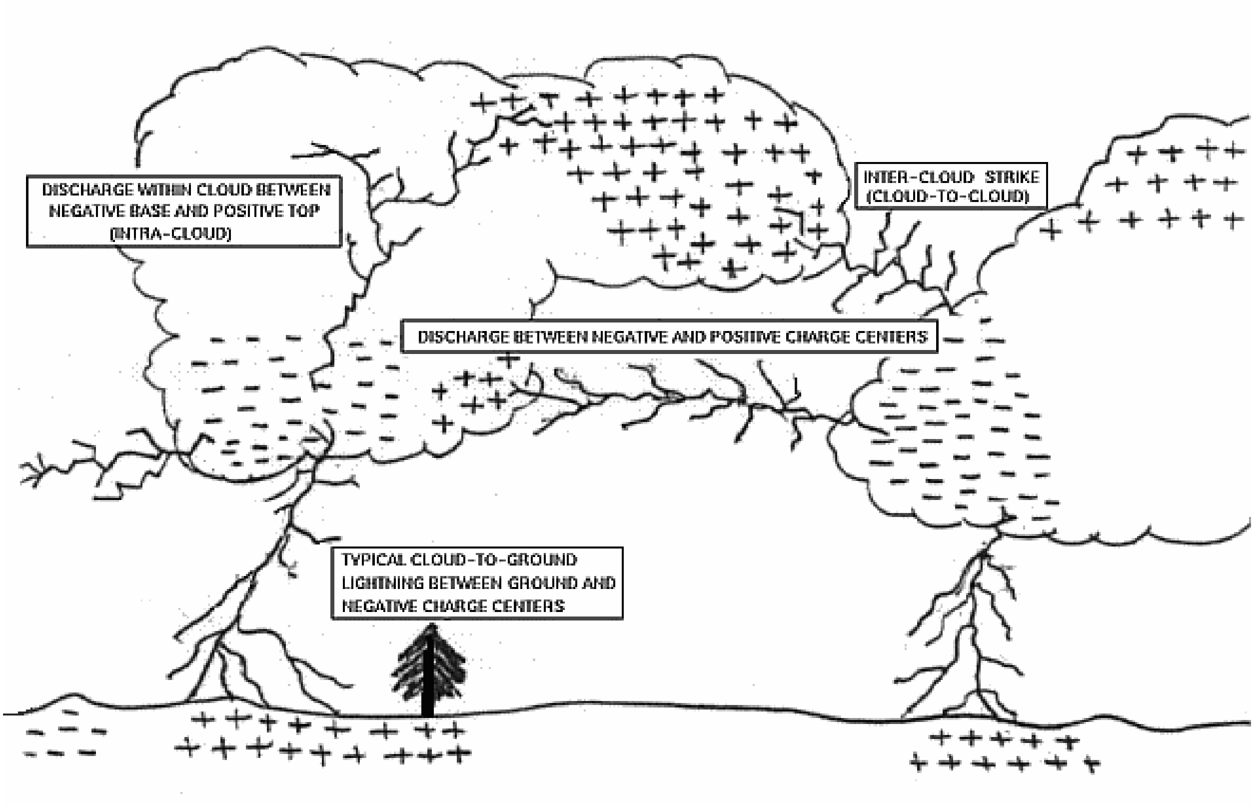
Picture: Lightning Conductor

- ∆ Placed on the top of tall buildings to prevent them from being struck by lightning during a thunderstorm.
- ∆ A device consists of a cooper strip with the one end fixed to a metal plate or water pipe buried in the ground.
- ∆ The other end is attached to sharp spikes above the rooftop.

Process of how flash of lightning happens.

- ∗ Thunderclouds contain a large quantity of negative charge on their underside and positive charge on their tops.
- ∗ Negatively charged cloud gathers over building, positive charges are induced on the roof.
- ∗ The force attraction between + and – charges can be so strong.
- ∗ Electrons suddenly jump from the cloud to the roof
- ∗ Producing a flash of lightning
- ∗ The spikes on the lightning rod allow positive charges to flow out from the spikes, thereby reducing the amount of induced charge on the roof.

* This lowers the chance of lightning striking the building.
* If lightning does hit the building, the lightning rod provides a route for electrons to pass into the ground without damaging the building.
* People can protect themselves from lightning by:
  - Taking shelter in a building or enclosed vehicle
  - Not using telephones during thunderstorms
  - Avoiding tall, solitary trees or other isolated objects in open areas
  - Avoiding water



1.4 Problems and Applications of Electrostatic

Problems and Hazardous of Electrostatic

- Flash of lightning
  - Need lightning conductor to prevent them from being struck by lightning during a thunderstorm.
- Hazardous of Static Electricity
  - A chain earthing a petrol tanker. This prevents electric charges building up on the tanker and reduces the chance of a fire or an explosion

Applications of Electrostatic

- Electrostatic precipitation
  - Wires inside the chimney are negatively charged and give similar charge to the ash particles
  - The negatively charged ash particles are attracted to positively charged metal plates inside the chimney walls
  - The ash particles are then removed by washing
- Car painting in the car industry.
  - To coat newly built cars with paint
  - The cars are given an electric charge
  - Paint from spray guns becomes charged by friction
  - The charged droplets are then attracted to the car instead of missing it

- The photocopy machine
  - A pattern of light and dark from the original copy is allowed to fall onto a positively charged plate
  - Charges leaks away from the area exposed to light
  - The unexposed area (i.e. the dark areas of the original copy) still carries positive charge
  - This positively charged image attracts negatively charged carbon powder (black).
  - The blackened image on the plate is then attracted onto a piece of paper with the help of positive charge placed under the paper
  - The paper is then heated to fuse the powder to the paper

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