Attractive and Repulsive Force Experiments Using Aluminum Collecting Sphere

NaRiKa Corporation

1. Learning Outcome

We have learnt that: there are two types of charges (static electricity), the same charge repels each other, while different charge attracts each other. In this sub-unit, we will go through an application experiment, where students are able to successfully interpret and present the results of their experiment using plus (+) and minus (-) signs.

2. Historical Background

In this sub-unit, we will use “Static Genecon” that generates static electricity continuously. This was developed by NARIKA Corporation in 2007, specially for students’ experiment to be done in a safer manner, generating less than 10,000 V, that is as intense as the static electric shock we often experience in our daily lives.

Historically, between 1880 and 1883, James Wimshurst (1832-1903, UK) invented the first Electrostatic Generator, so-called “Wimshurst Machine (influence generator)”. As shown in the photo below, this consists of two disks, Leyden jars and other parts. The mechanism to store electrical charge in the Leyden jars is rotating each of the two disks inversely to each other. This mechanism is characterized by generating static electricity using the principle of electrostatic induction instead of using friction. Normally, this generator generates higher voltage and larger current compared to Van de Graaff.

Later, in 1929, Robert J. Van de Graaff invented high voltage electrostatic generator, so called: ”Van de Graaff generator”. Compared to the Wimshurst Machine, it can generate high voltage with relatively small amount of current, because of its mechanism to store static electricity into collecting sphere generated by the friction between rotating belt and rollers. Nowadays, Van de Graaff generator is typical static electricity generator widely used for demonstrating static electricity in schools.

Wimshurst machine

http://en.wikipedia.org/wiki/Wimshurst_machi

Van de Graaff generator

(Narika B10-1324)

3. Electrostatic Generator: "Static Genecon"

We already know that if we rub piece of plastic with felt or different kind of cloth then static electricity will be generated. And we have in various ways confirmed properties of above mentioned way of generating static electricity. As a result, we have learned among other things as well, that electrostatic charge has two kinds. Furthermore, we can store static electricity because of the invention of Leyden jar and Electrophorus. By using them we can store greater amount of static electricity, thus conducting experiments with large amount of static electricity. Because of that invention research about static electricity accelerated in the past.

In 1929, Robert J. Van de Graaff (1901-1967, USA), with purpose to invent particle accelerator, invented high voltage electrostatic generator, so called: "Van de Graaff generator". Van de Graaff generator can generate low electric current, but it can accumulate high amount of voltage. It is often used for demonstration experiments in schools.

Static Genecon
(Narika B10-1324)

In this unit, we will use "Static Genecon" that generates static electricity continuously in the same way as Van de Graaff generator to perform various experiments. For example: Charge & Discharge, or Repulsion and Attraction experiments, by analysis of the behavior during experiments, let's deepen our understanding of static electricity.

"Static Genecon", developed by NARIKA Corporation, is a smaller version of Van de Graaff generator. Below you can find a simple explanation of the operating principle. The basic principle is: by rubbing two things against each other, static electricity is generated.

In drawings below, we can see simplified internal structure of Static Genecon. Felt reinforced with metallic copper is in contact with drum made of PVC. Also, to collect electricity charge generated on the surface of the PVC drum, there is a collector made of metal (Figure 1).

If you rotate slowly the handle of Static Genecon, PVC drum will rotate and rub felt. As a result of the friction, on the surface of PVC drum negative charge, and on the felt positive charge will

be generated. On the surface of nonconductor static electricity will not move, therefore when PVC drum is rotated, negatively charged static electricity formed on the surface of PVC drum is transferred to the collecting plate.

Because collecting plate and PVC drum are not in contact, due to negative charge on the surface of PVC drum, collecting plate will be induced and negative electric charge on the surface of PVC drum will be neutralized. Because of the electrostatic induction of collecting plate, negative charge will easily move inside the conductor. On the other hand, positive charge generated on the surface of felt will be supplied by negative charge from metallic copper plate inside of the felt, therefore it will be electrically neutralized (seemingly it looks like transference of positive charge. See Figure 2 and Figure 3.).

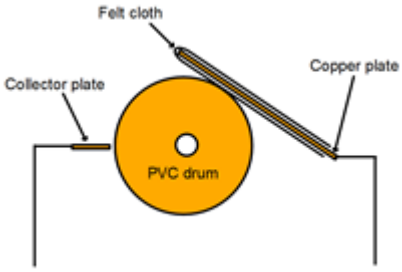


Figure1

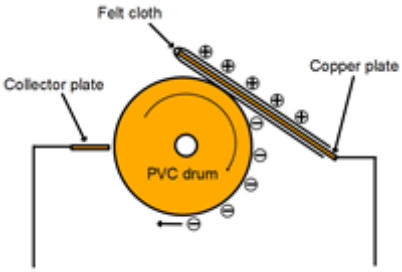


Figure2

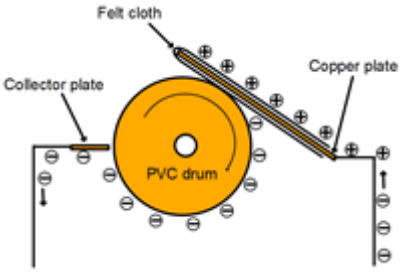


Figure3

4. Attractive and Repulsive Force Experiments Using Aluminum Collecting Sphere

We have performed experiment related to the attractive and repulsive force of static electricity (Coulomb force) with charging rod and electric pendulum. In this sub-unit, we will use Static Genecon and Aluminum collecting sphere and conduct experiments with attractive and repulsive force of static electricity.

1. What to prepare

- Static Genecon: 1 pc (Narika B10-1324)
- Aluminum Collecting Sphere: 1 pc (Narika B10-1324-03)
- Tissue paper: Some pieces


Aluminum Collecting Sphere
(Narika B10-1324-03)

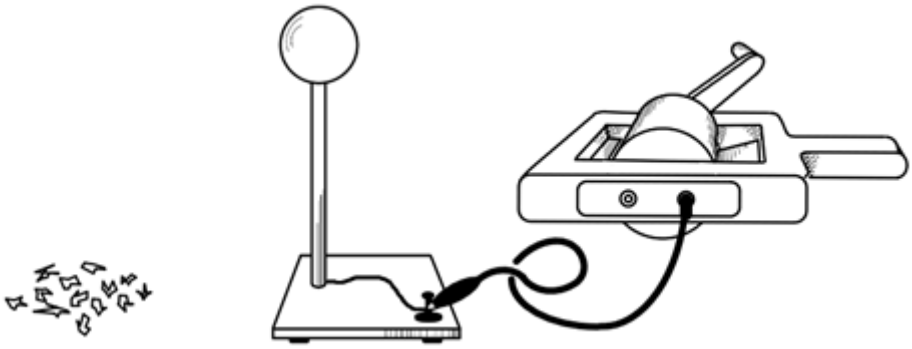
2. Experiment procedure

1) Make pairs.

2) To the red terminal on Static Genecon, connect included red cable, do not use included black cable.

3) To the terminal at Aluminum collecting sphere, connect red cable from Static Genecon as shown at the drawing below.

4) Tear the tissue papers to make around 10-20 small pieces of size around 3 - 5 mm and spread them on the table roughly.



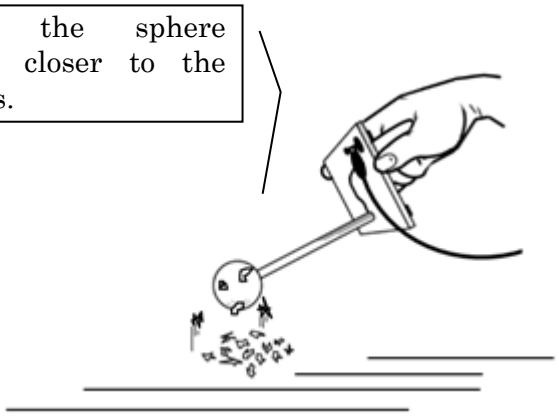
Pieces of tissue paper Aluminum collecting sphere Static Genecon

5) One person turns slowly handle of Static Genecon.

6) The other person holds the Aluminum collecting sphere above pieces of tissue paper. Do not touch the electrode.

7) Put Aluminum collecting sphere slowly closer and closer to the scattered pieces of tissue paper.

Bring the sphere slowly closer to the tissues.

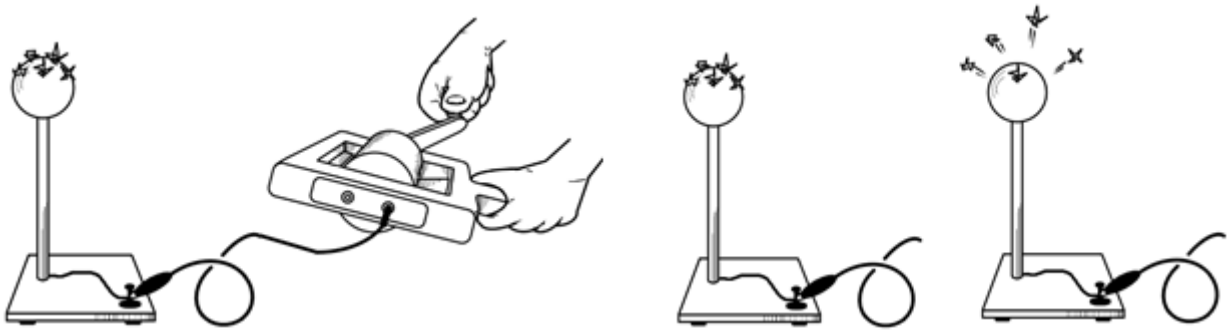


8) Wait until the pieces of tissue paper start jumping to the Aluminum collecting sphere.

9) In a state in which pieces of tissue paper are attached to the Aluminum collecting sphere, place it slowly back on the table.

10) Continue rotating the handle of Static Genecon.

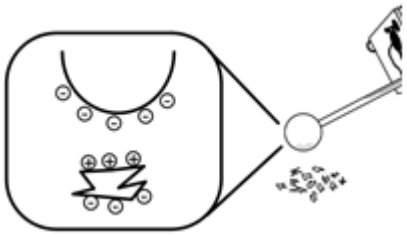
11) After a while, pieces of tissue paper start to fly.



5. Question

Pieces of tissue paper were attached to the Aluminum collecting sphere surface at first, but despite that, they flew from the sphere. Think about reason why and explain about it below.

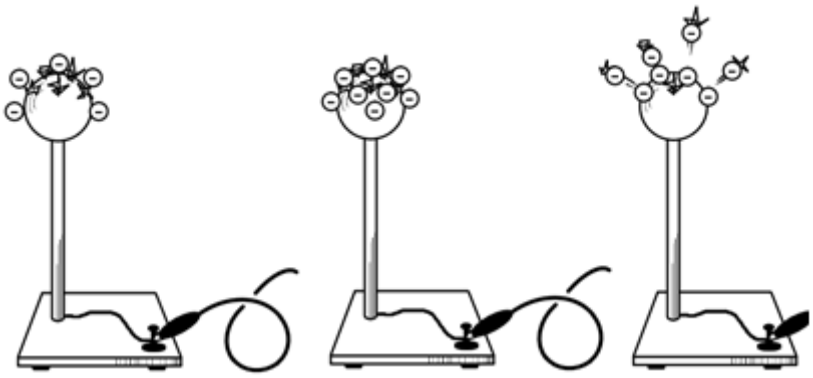
For example, as shown by the figure on the right, when a sphere of which surface is negatively charged is brought close to tissues, electrostatic induction occurs in the tissues of which surface (closer to the sphere) becomes positively inducted.



Since the tissues are light enough, they will transfer to the sphere when the sphere comes close enough to the tissues for both the plus/minus charge to draw towards each other.

Tissues transferred to the sphere will be electrically neutralized by the minus charge on the sphere. Then, as a whole, the tissues will be negatively charged after receiving minus charge from the sphere.

As the result, becoming the same type of charge, the tissues will repulse the sphere by flying from it (See figures below).



1 2 3

Keywords

- There are two types of charges (static electricity).
- The same charge repels each other
- Different charge attracts each other.
- Electrostatic Induction phenomena occurs when a charged material is brought near conductor (metal), in which heterogeneous charge is generated.

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