Attractive and Repulsive Force Experiments Using Electric Pendulum

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 an Electric Pendulum (as shown below) other than the "Pith-ball Electroscope" invented by John Canton (1718 - 1772, UK) in 1754 already covered in the previous Unit 2.

Structure of the Electric Pendulum introduced in this sub-unit is an installed conductive ball between two electrodes inside a transparent circular cylinder. When one of the electrodes is charged, due to electrostatic induction, the conductive ball's surface closer to the electrode will be charged with static electricity of the polarity opposite to the electrode. This is why the ball is attracted by the electrode rolling toward it.

Once the ball touches the other electrode, it is electrically neutralized, and then will acquire an electrical charge from the electrode, until the ball is homogeneously charged and repulses the electrode receding away from it. By repeating this process, the ball looks like a pendulum making back-and-forth motion between the electrodes.

Electric Pendulum
(Narika B10-1324-01)

Large Electric Pendulum
(Narika B10-1131)

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.).

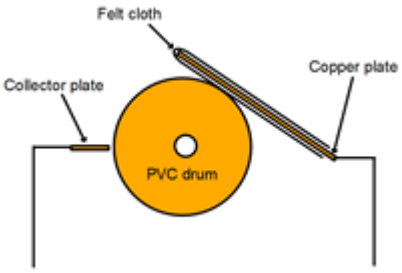


Figure1

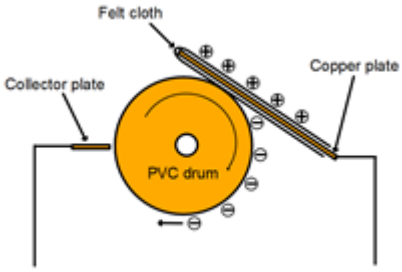


Figure2

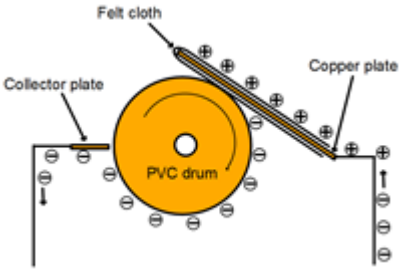


Figure3

4. Attractive and Repulsive Force Experiments Using Electric Pendulum

In this sub-unit, we will perform experiment related to the attractive and repulsive force of static electricity (Coulomb force) using a Conductive sphere (a ball used as an Electric pendulum) and Static Genecon.

As the typical principle of static electricity, we will confirm the phenomena of electrostatic induction, attractive and repulsive force. Let's start our experiment with analyses of this phenomenon.

1. What to prepare

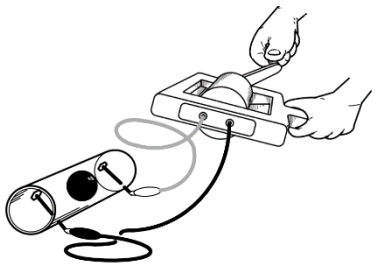
- Static Genecon: 1 pc (Narika B10-1324-W0)
- Electric Pendulum EG-01: 1 pc (Narika B10-1324-W1)

Electric Pendulum EG-01
(Narika B10-1324-W1)

2. Experiment procedure

1) Connect Static Genecon and Electric pendulum with cables.

2) Start turning handle of Static Genecon slowly.

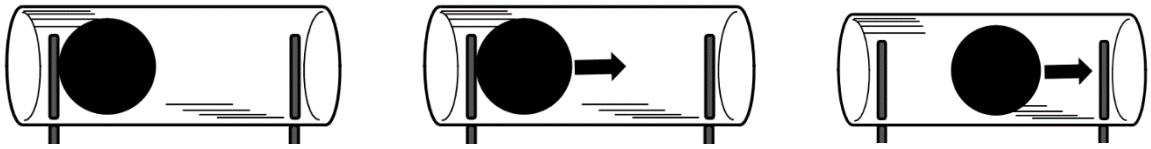


* If experimental items are placed on metallic table, place a plastic board beneath the cylinder of Electric Pendulum.

* Keep the cylinder in horizontal position during your demonstration.

3) Conductive sphere touches the electrode for a moment.

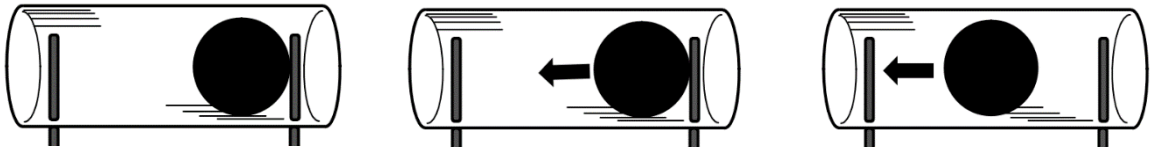
4) After a while, conductive sphere moves away from the electrode and starts moving towards the other electrode.



* At the beginning, make sure the sphere is in touch with the electrode

5) Conductive sphere touches the other electrode.

6) After a while, again conductive sphere moves away from the electrode and starts moving towards the initial electrode.



5. Questions

1. Please explain the movement of conductive sphere by drawing Static Genecon and the cables with the positive charge sign (+) and negative charge sign (-) on below figures.

Explain whole the process of the experiment by using figures based on the premise that the experiment starts when the sphere of the Electric Pendulum is in touch with the negative (-) electrode.

1) When "eight (8) pieces" of negative (-) charge is provided by Static Genecon at one of the electrodes, the same amount of "eight (8) pieces" of positive (+) charge is generated at the other (positive) electrode. As long as the sphere keeps contacted with the negative electrode, the "eight (8) pieces" of negative (-) charge exists equally throughout the sphere and negative electrode.

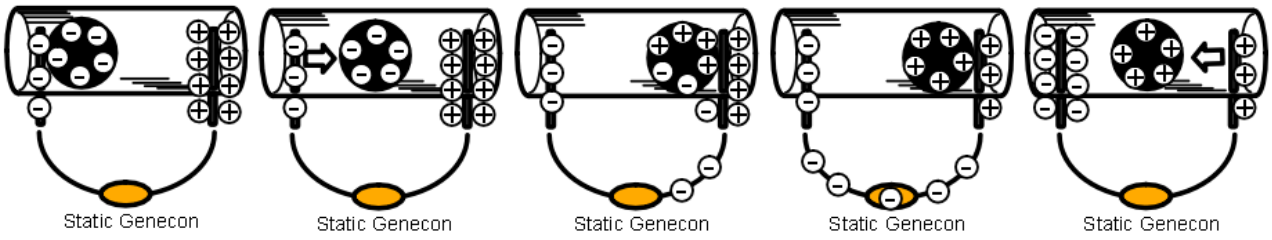
2) Then, since the same type of electrical charge repels each other, repulsive force is generated between the negative (-) charge on the negative electrode and negative charge on the sphere, which pushes the movable sphere away from the negative electrode. Then, since the different type of electrical charge attracts each other, positively (+) charged other electrode becomes attracting the negatively (-) charged sphere when the sphere comes to the midway of the cylinder.

3) Once the sphere touches the positive (+) electrode, the negative (-) charge on the sphere is charged toward the positive (+) electrode. Then, the sphere becomes seemingly-positively-charged thing.

4) Then, when the sphere is sufficiently positively charged, because the same type of electrical charge repels each other, the sphere gets away from the positive (+) electrode.

5) Then, when the sphere comes to the midway of the cylinder, it is attracted by the negative electrode.

During the experiment, aforementioned process is repeated.



1 2 3 4 5

2. Based on the description written by yourself above, explain the reason why the sphere after touching one electrode started to move towards the other electrode.

1) Until the sphere physically touches the electrode, each of them remains differently charged. In other words, if the sphere is charged negatively, the electrode being approached by the sphere is charged positively, because the sphere comes close to the positively charged electrode from the negatively charged electrode since the different type of electrical charge attracts each other.

2) Once the sphere touches the electrode, electrical charge on each of the sphere and the electrode neutralizes, which means the negative and positive charge negates each other. Then finally, the electrical charge on the sphere becomes positive (+) after being affected by the electrode in contact.

3) Once the charge on the sphere surpasses the (same type) charge on the electrode, the repulsive force becomes majority, and then the sphere starts going away from the electrode since the same type of electrical charge repels each other.