615-3090 (10-092) Electrostatic Studies Kit

Warranty

We replace all defective or missing parts free of charge. Additional replacement parts may be ordered toll-free. All products warranted to be free from defect for 90 days. Does not apply to accident, misuse, or normal wear and tear.

Concepts Taught: Electrostatic Attraction and Repulsion; Electrostatic Conduction and Induction; Charge Identification. Charge distribution if a conductor; Electrostatic field
Curriculum Fit: Physics Sequence Electricity and Magnetism. *Static Charge.* **Grades 3-8**

Materials Needed:
Electroscope (optional)
*Use from **615-3075 Electroscope Kit** or substitute your own.*

Product Description

- **Proof plane** (Transfer Ball) to "move" charges one body to another. Hold by insulator handle. Ball "carries" the charge.
- **Friction rods, 5** (acrylic, glass, nylon, PVC and polyethylene, each 10 x 200 mm and labeled) and **surfaces** (acetate cloth) are basic materials for generating electrical charges by rubbing rod against surface. (You can add material like *a hard rubber comb, flannel, wool, and silk cloth and polyethylene film)*.
- **Conductive ball** has a hook to suspend with a thread or fishline. Used to detect charges and to study attraction and repulsion between ball and charged bodies.
- **Neon Lamp** helps detect presence of electrical charges. The brightness of its glow tells the intensity of electrostatic fields.
- With the **electrophorus** you can generate, store and transfer small quantities of electrostatic charges. It consists of a metal disc with vinyl handle and acrylic charge plate, 30 cm square and 10 mm thick.
- **Pith Balls** are lightweight masses hanging from strings that demonstrate repulsion from or attraction to charged bodies. Six (6) are included.

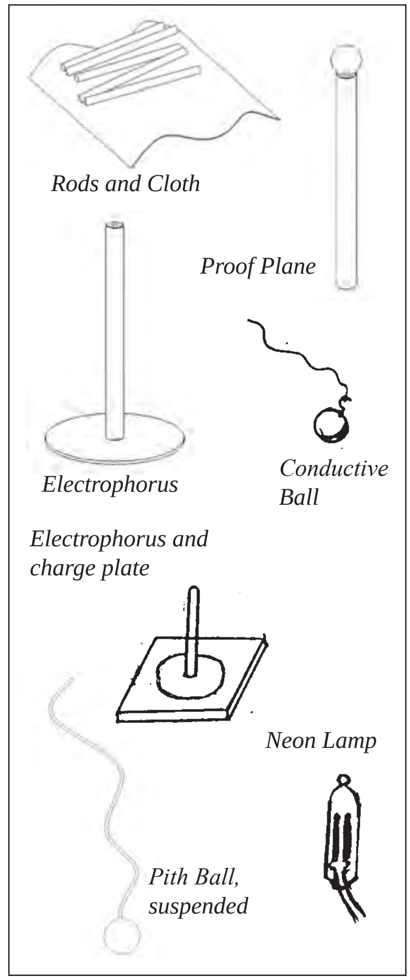
Introduction

This is a basic kit for the study of electricity. It concentrates on the nature and behavior of the electrical charge which is the fundamental unit of electrical energy. While designed for grades 3 up, it is also simple and safe enough for younger groups.

Theory

What is electricity? A *flow* of electrons between two points of a conducting body much like the flow of liquids from higher to lower levels.

What are electrons? Tiny particles carrying an electric charge. All bodies contain electrons in their atoms. Even though electrons are charged, the atoms and the bodies which they make up are normally electrically neutral (uncharged). This is because each atom holds its electrons revolving around a nucleus containing an equal number of particles called protons. Since protons carry a charge opposite that of electrons, the atom as a whole remains uncharged. Therefore the bodies are uncharged in their normal state. Since by convention electrons carry a negative charge, protons are electrically positive.



Experiment 1: Friction Generates Electrical Charges

You Need:
- Lightweight materials (Paper, straw, feathers etc.)

Procedure:
1. Choose a friction rod and surface (i.e. acrylic rod and acetate cloth).
2. Cut out small bits of light paper (or straw, packing material, feathers) and spread on a table.
3. Hold one end of rod and rub the other end with fabric.
4. Bring rubbed end close to the

material on the table.
5. Watch material fly and stick to the rod!

Different students can use different rods and surfaces. Compare cases!

For ***older students,*** *use uniformly cut out paper (as from a hole puncher) in order to see if the rods pick up equal amounts of material when rubbed more.*

Plot a ***graph*** *with the number of paper pieces (Y-axis) against the length of time (or number) of rubs received.*

Discussion:

Why do rubbed rods behave this way? Because the rods become charged by friction and attract light-weight material electrostatically. *See Experiment 3.*

How do the rods become charged? All matter has a fraction of its electrons in a relatively loose state. When bodies touch each other or come into close contact by rubbing, the surface electrons from one body "get loose" and move to the other surface. The bodies are no longer neutral; the one which gains electrons is "negatively charged" and the other body loses electrons and is positively charged.

Different materials have different affinities for gaining or losing electrons. Silk gains electrons when rubbed against glass and leaves it positively charged. Fur, flannel and wool lose electrons and charge amber or hard rubber negatively.

Frictional generation of electric charges was how electricity was accidentally discovered by the ancient Greek philosopher Thales 25 centuries ago. He observed that amber (*Elektron* in Greek) attracted light material like straw and feathers after being rubbed with fur. He thought amber (electron) was lost in the fur, but today we know that amber draws electrons from the fur to become negatively charged.

In generating electric charges, friction does not create more electrons. Electrons simply move between surfaces, keeping their total number the same. Electrons get redistributed and are not created or destroyed.

Experiment 2:
Charged Bodies Can Be Discharged

You Need:
- Rods
- Pieces of paper, straw
- Metal surface

Procedure:
1. Take the charged rod, touch with your finger or to a metal surface (i.e. door knob).
2. Carry the rod to pieces of paper (or straw, feather etc.) as before. Use **new** pieces of paper for best results!
3. The rod now cannot pick up material. It has *lost* its charge.
4. Compare cases using different combinations of rods and surfaces. In particular, use a positively charged rod (glass rubbed against silk) and a negatively charged rod (acrylic rubbed against wool or fur).
5. Observe that both kinds of charges can be removed by discharging.

Discussion:
In charging, there is redistribution of electrons between two bodies so one is positive while the other is negative. Discharging makes charged bodies neutral by redistributing electrons. During discharge, electrons move through a transporting medium. They use your body or door knob to be transported **to** the ground (negative rod) or **from** the ground (positive rod).

Certain substances are better transporters or **conductors** of electrons than others. Metals are good conductors. The rods and surfaces in this kit are not. They are **insulators.**

There is electrostatic cling from friction when you rub against car seats, walk with shoes on carpets or in clothes when they rub against each other in a dryer. The "shock" you get when touching a doorknob or car door is because these are discharging into them through you.

Spark is discharge through ionized air.

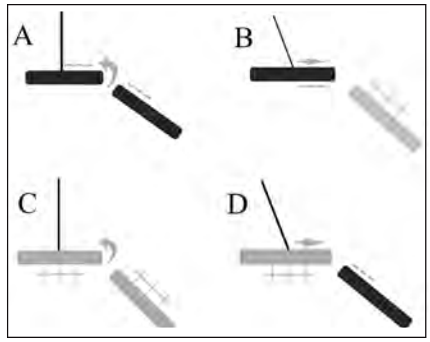


Figure 2 - a. Two negative rods swing away from each other.
b. Negative rod pulled toward positive.
c. Positive rod pulled away from positive.
d. Positive rod pulled toward negative.

Experiment 3:
Like Charges Repel; Unlike Charges Attract

You Need:
- Charged Rods
- Fishline
- Stand
- Pith Balls (*Procedure 3*)
- Graphite Ball (*Procedure 4)*
- Electrophorus *(Procedure 4)*

Procedure 1:
1. Charge acrylic rod negatively by rubbing it against acetate cloth.
2. Suspend with a fishline or string from a stand or high surface.
3. Charge another acrylic rod negatively and bring its end near the charged end of the suspended rod.
4. Observe that the first rod swings away from the charged end of the other (*Fig. 2*). The two negative charges **repel** each other.
5. Bring positive rod (glass rubbed with silk) toward charged end of suspended rod.
6. Watch as it is pulled toward the other. A positive charge **attracts** a negative one.
7. Suspend the charged glass rod and bring another charged glass rod close to the first one. They should repel each other. Two positive charges also repel each other. **Like charges repel while unlike charges attract each other.**

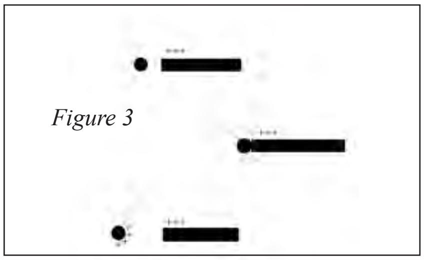


Figure 3

Procedure 2:

1. Instead of a charged rod, suspend a pith ball (see *Fig. 3*)
2. Bring a negatively charged acrylic rod or positively charged glass rod close to it. Observe that the ball is attracted to the rod.
3. Touch the ball with the rod.
4. Watch the ball repel the rod.
5. Move the rod close. You will be chasing the pith ball!

Procedure 3:

1. Bring two rods, one charged (either positively or negatively), the other uncharged, close to a suspended pith ball. Approach it from opposite sides simultaneously. (Uncharge pith ball by touching it with fingers or wall before you begin.)
2. Let the ball be attracted to the charged rod. Then touch it.
3. The ball will be repelled by the charged rod, as before.
4. Let the ball touch the uncharged rod on the other side. Watch as it bounces off. If it now touches the first rod, it bounces off it too! You can actually keep the ball going back and forth between the two!

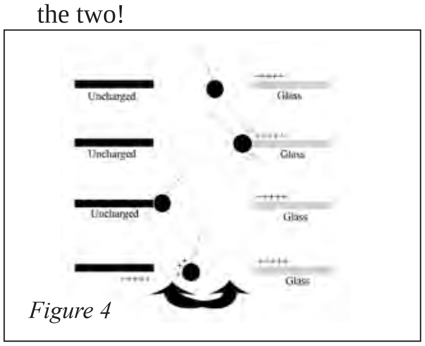


Figure 4

Procedure 4:

You can show the same effects as in Procedure 2 by using the conductive ball instead of the pith ball and an electrophorus in place of charged rods. See *Figure 5.*

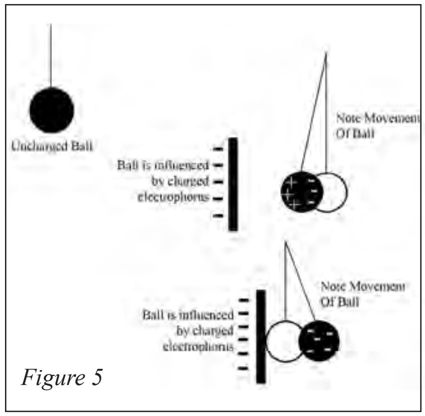


Figure 5

Discussion:

Electrostatic attraction takes place between opposite charges and repulsion between like charges *(Procedure 1)*. The forces of attraction/repulsion come from the electric field surrounding charges (*Fig. 6*). An isolated electron in the field moves towards the positive pole (charge concentration) and away from the negative pole.

The experiments in *Procedures 2 and 3* demonstrate the concept of **electrostatic induction,** whereby a charged body induces an opposite charge in an uncharged body near it. (Example - charged rod held close to uncharged pith ball.) Molecules of the pith ball reorient themselves such that their electrons are closest to the positive end (*Fig. 7).* In doing so they acquire the opposite charge.

Subsequent to induction, there is attraction between pith ball and rod due to opposite polarity between them. When they touch, electrons are directly transferred by conduction. The like charges face each other and therefore repel. The sequence "induction, attraction, conduction and repulsion" explains the behavior of the pith ball in *Procedure 3.*

Advanced Concepts:

- Electrostatic attraction and replication of a DNA molecule; the passing on of genetic characteristics during cell division.
- Ionic vs chemical bonds.

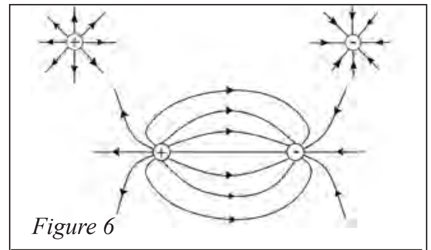


Figure 6

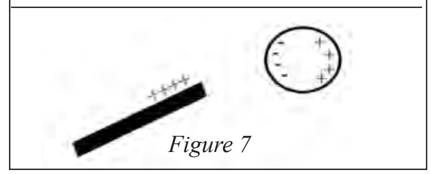


Figure 7

Experiment 4:
Separating Mixtures Electrostatically

You Need:

- Salt and pepper
- Paper
- Acrylic charge plate
- Acetate cloth

Procedure:

1. Spread mixture of salt and pepper evenly on a sheet of paper laid flat.
2. Place plate above the paper supported on two blocks or books as in *Figure 8.*
3. Charge plate negatively by rubbing its top with acetate cloth.
4. Watch pepper particles jump to the bottom of the plate (induction, attraction), fall (contact, conduction, repulsion) and bounce again.
5. Cut out a shape from paper such as the number “8” and tape to the surface of the acrylic plate. Since the plate does not get charged in the parts covered by the paper, the pepper is finally attracted and held to the covered parts.

Discussion:

This illustrates the principle of the photocopier machine, where toner dust is attracted to a sheet of paper by electrostatic attraction and fixed by heating. Other examples include the filtering in air pollution devices and TV monitor screens.

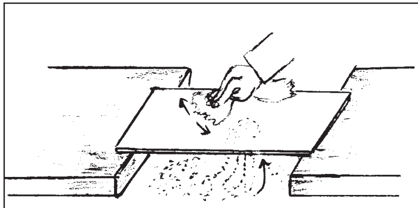


Figure 8

Experiment 5: Storing/Transferring Electrostatic Charges

<u>You Need</u>:
- Electrophorus
- Acrylic plate
- Neon lamp (optional)

<u>Procedure:</u>

*Charge an electrophorus (*Fig 9).

1. Rub plate with polyethylene so plate acquires negative charge. Place flat on table.
2. Holding electrophorus by handle, bring disc close to acrylic plate. By induction, the top acquires negative charge (electrons reorient and are driven to the top).
3. Discharge by touching a finger to the top. Electrons flow through your body.

Show discharge with a neon bulb. Hold one lead with your finger and touch the disc top with the other lead; the bulb glows to show a charge is flowing.

4. Remove your finger. The disc has a positive charge (fewer electrons).
5. Pull away disc from plate, holding it by handle. Electrophorus is positively charged.

You can place the disc on the charged plate in Steps 2, 3 and 4. Since the contact is only at a few microscopic projections to which the insulator does not conduct electrons, the electrons eventually leak away.

6. Transfer charges from the reservoir built up in the electrophorus with **a proofplane or transfer ball**.
   Charge an electroscope (*Fig. 10.*)

An electroscope detects and identifies electrical charges. Presence of charge makes its vanes diverge (similar charges acquired by both). When uncharged, the vanes remain neutral and collapse.

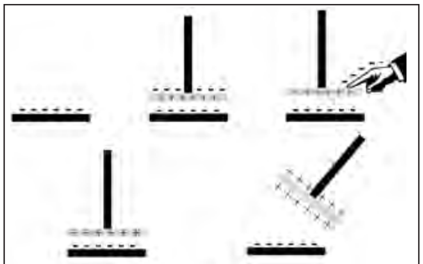


Figure 9 - Charging an Electrophorus

- Holding proofplane by handle, touch disc with ball. The ball acquires a positive charge by contact (conduction).
- Move proofplane to electroscope and touch ball to its terminal.
- Watch vanes diverge. The positive charges repel each other.
- You have used the proofplane to transfer positive charges. Can it transport negative charges? Experiment. Discharge proofplane by grounding it. Repeat with a reservoir of negative charges. At first, the vanes collapse. You bring more charges, they diverge. Why?

<u>Discussion:</u>

Figures 9 and *10* show the charging of the electroscope by conduction. The initial collapse of vanes is due to neutralization of vanes by the negative charges being deposited. Subsequent deposit of negative charges make the vanes diverge because like charges were acquired. The proof plane is physically transporting electrostatic charges.

Static vs current electricity: An electric current (flow of electrons) along a conductor can be generated by a perpendicularly moving magnetic field. Think of the electrical current as a flowing river, the generators as pumps and the wires as pipes. By contrast, static electricity is stationary like water in a lake. Provide a channel and electrostatic charges can also flow and become current electricity.

Static electricity can be generated using mechanical transportation. Electrostatic charges can be carried and moved as electrons adhere to matter. If you consider an electric current a flow of liquids from a higher to a lower level, moving charges are like transporting liquids with a dipper and pail.

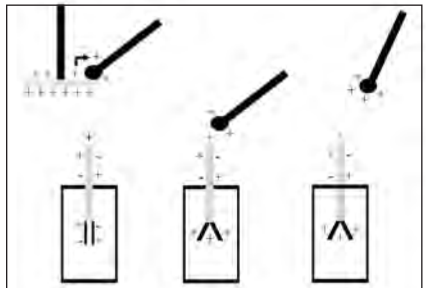


Figure 10 - Charging an Electroscope

Maintenance:

Protect insulating materials from salt spray, chemical flames and perspiration, which conducts away electric charges. Remove moisture film buildup with a rinse of distilled water.

Your experiments are best performed in a dry room with dry hands.

At humidities over 80%, lint may cause short circuits or act as discharge points. Damp lint diminishes the potential of an electrophorus and makes it less effective.

Avoid radiation, open flames etc. that might ionize nearby air. These will slowly discharge the charged bodies.

Charge Generators:

Excellent in all humidities:

Sulfur	Paraffin wax
Polystyrene	Polyethylene
Pure gum rubber	Vinyl plastic.

Excellent at low humidities are:

Porcelain Glass	
Mica	Acrylic plastic
Epoxy plastic	Polyester resins
Shellac	Bees wax.

Unreliable at moderate humidities:

Wood products	Paper products
Hard rubber	Phenolic resins
Synthetic fur	Cloth of all kinds
Soft glass	Rubber

(Some rubbers and plastics are treated to make them slightly conducting).

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