615-3095 (10-094) Faraday Cage Kit

Warranty and Parts:

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

Common Charge Generators:

Excellent at all humidities are:

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 are:

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

(some rubber and plastic products are treated to make them slightly conducting).

Additional Materials Needed:

If not available elsewhere, these materials may be obtained from **Science First**.® *Contact us for details.*

- **Foil leaf electroscope**
- **Electrophorus**
- **Proof Plane**

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**

Use and Care of Equipment:

For best results, maintain materials between use by taking the following precautions:

1. Protect insulating materials from salt spray, chemical flames and perspiration. They coat them with a film of moisture which may conduct away electric charges, thereby affecting your experiments. Remove any film buildup with distilled water.
2. Your experiments are BEST performed in a dry room. Avoid handling the material with moist hands.
3. At high humidities (over 80%), lint strands may cause short circuits or act as discharge points.Be aware that damp lint diminishes the maximum potential of metal surfaces and makes an electrophorus less effective.
4. Watch for any radiation, open flames or other media that might ionize the nearby air. These will slowly discharge the bodies you have charged and are testing with the electroscope.

Experiments and Activities

[For a background on electrostatics in general, see the instructions in companion kits ***615-3090 Electrostatic Studies*** *and* ***615-3075 Electroscopes****. Discussions of particular value are: electric field around charges; attraction and repulsion in electric fields; discharge; transfer of charges.]*

Experiment 1

The Electric Field Inside a Conductor is Zero: Faraday Cage Experiment.

Procedure:

1. Set up an electroscope with its foil leaf assembly. (If using Electroscope Kit **615-3075**, set it up with the ball terminal.)
2. Make sure the Faraday Cage is on its metal base, mount base on insulated stand (caplug). Place the electroscope carefully within the cage; cover it.
4. Charge an electrophorus. *(Review the electrophorus in kit* ***10-092.****)*
5. Bring electrophorus in contact with outside of the cage at various points either directly or by means of a transfer ball. *(See kit* ***10-092.****)*
5. Notice the electroscope shows no deflection.
6. Set up another electroscope (either with a disc or ball terminal) and bring it close to the cage on the outside.
7. Observe the deflection (and the intensity of it) in its vanes.

Conclusion:

The cage has acquired a charge and all of the charge is on its outside! There is no electric field (because of no charge) inside it, in spite of the high potential buildup on its outer surface.

Discussion:

Q. Why did the cage not acquire any charge inside it - in its hollow part?

A. It is because the cage is made of metal and metals are good conductors. When charges are at rest, the electric field inside a good conductor is always zero, and any net charge on it distributes itself on the outer surface. This is because a good conductor has free electrons and any force experienced due to an electric field would easily drive them to positions until the net force on them would become zero. In the case of a negatively charged cage, for example, if there did exist an electric field within it, the electrons would flee from the center all the way to its surface in order to get away from one another as far as possible. This would leave no net charge on the inside of the cage.

(**Note:** Interestingly, if you placed a positive charge within the cage, the electrons would be forced to be on the inner surface this time so the outer surface is positively charged. You can verify this by introducing a positively charged proof plane into the Faraday Cage, while bringing a charged test electroscope near the outside of the cage at the same time.)

See charge identification in **615-3075.** This is a case of electrostatic induction. Review discussion of induction in the instructions for Kit **615-3090.**

Secondly, any electric field that exists is always **perpendicular** to the surface outside of the conductor.

The above properties relate only to conductors. Since nonconductors have no free electrons, an electric field can exist inside them. The field outside a nonconductor need not make a right angle with the surface.

The fact that there is no electrostatic field inside an electrically conducting container has interesting practical applications. A person in a metal airplane or automobile is less likely to be struck by lightning. Lightning is a phenomenon where clouds become highly charged giving rise to electrostatic fields of high voltage (large difference between positive and negative charge accumulations); their negatively charged bottom surfaces can discharge into the positively charge tops of other clouds or to the positively charged ground. Such discharge or "lightning: can bypass the inside of a metallic container, and occur through the surface of the container.

Experiment 2

Surface Distribution of Charges

Procedure:

1. Set up the Faraday Cage as in the previous experiment and charge it using the electrophorus as before.
2. Discharge a transfer ball (proof plane) and use it to gather some surface charge from the middle sides of the cage.
3. Take it to a second electroscope for testing. Watch the vanes deflect.
4. Discharge the proof plane, use it to gather some charge from the top edges of the cage (that has projections/corners) and test it with the electroscope. Observe the deflection and its greater intensity as compared to the previous time.

Conclusion:

There is greater charge accumulation at corners (projections; points) than on flat surface areas.

Discussion:

Q. Why do charges accumulate at projections rather than on flat areas?

A. Projections present a special case. The surface electrons experience forces of repulsion between each other - specifically, between those on either side of the corner and at the corner itself. In the first case, each electron experiences an equal force from both of its neighbor electrons but in opposite directions. In the second case, the forces on the electron at the corner tend to push it off the projection. Thus a transfer ball would more easily pick up charges from projections than from flat surface areas.

Experiment 3

Discharge from a Point

Procedure:

1. Charge electrophorus.
2. Place it on the insulated base.
3. Place an uncharged electroscope (with ball or disc terminal) near the electrophorus.
4. The pronounced deflection in its vanes indicates electrostatic charge in the electrophorus.
5. Hold the mounted point by its handle. Pointed toward the air, touch its head to the electrophorus
6. Observe the drop in deflection of the electroscope, indicating a discharged state of the electrophorus. The charge has gone off the point into the air (there has been a discharge through the point.)
7. Recharge the electrophorus and repeat the experiment, with a slight variation. After touching the point to the electrophorus, aim it at the terminal of another electroscope. (Make sure this is discharged and not too close to the electrophorus.)
8. The second electroscope will show deflection confirming the discharge occurring form the point.

Discussion:

The phenomenon of discharge from a point has a fascinating practical application - the lightning conductor. As in Experiment 2, lightning occurs when large negative charges from bottoms of clouds induce large positive charges on the ground and then discharge through a conducting medium. Such discharge would choose a conducting surface, when available, rather than its inside (since the field inside is zero), and better still, a point or projection on this surface (as in this experiment) if available. This is what happens in the case of a "lighting rod", a tall conductive rod with a sharp point installed on a building for the purpose of "deviating" the path of a lighting discharge by providing it with a point through which the charge can escape.

About Electrostatic Materials

Electrostatic charges are very small and voltages can be high. Therefore, charges can be conducted away by materials that you would ordinarily consider insulators/poor conductors. Some unreliable insulators are: wood, rubber, paper, leather, wool and cotton.

Water is a conductor of electricity. As water readily adheres to glass and minerals, more so at high humidities, glass, paper and wood are often poor insulators.

Finger prints and salt spray are electrically conductive. Wash the electrophorus base and handle with distilled water. Do not use soap or detergent.

A sheet or bag of polyethylene film will generate a charge in almost any humidity condition, when rubbed against polystyrene or sulfur. In this sense, these materials aresuperior to fur, glass and hard rubber.