寧波東方理工大學
EASTERN INSTITUTE OF TECHNOLOGY, NINGBO

Laboratory Report for College Physics

Electrostatic Experiment

Name: 贺嘉杰	Date: 2026/01/17	Grade: 2025
Student ID: 2510016	Major: /	Instructor: 梁阿坤

Abstract: The purpose of this experiment was to investigate the fundamental principles of electrostatics, specifically the methods of charging objects by friction, contact, and induction, and to verify the law of conservation of charge. Using a Faraday Ice Pail and a Wireless Charge Sensor, I measured the electric potential generated by charged disks under various conditions. The results from the friction experiment demonstrated that rubbing two neutral materials generates equal and opposite charges, with the sum of the charges remaining near zero, validating the conservation of charge. Experiments on contact charging showed that touching a conductor transfers charge of the same sign, while induction charging demonstrated that grounding a conductor in the presence of a charged object creates a charge of the opposite sign.

1 Introduction

Electrostatics is the study of stationary electric charges. Central to this experiment is the concept that charge cannot be created or destroyed, only transferred—the Law of Conservation of Charge. $\Delta Q_{\text{total}} = 0$.

1.1 Objective

The primary objective is to use a Faraday Ice Pail to investigate three distinct methods of charging: friction, conduction, and induction.

1.2 Physical Principles

The experiment relies on the Faraday Ice Pail, a conductive mesh cylinder electrically isolated from a grounded outer shield. When a charged object is placed inside the pail without touching it, an equal magnitude of charge is induced on the inner surface of the pail, while a charge of the same sign as the object is driven to the outer surface (and the connected sensor).

The voltage V measured by the sensor is directly proportional to the charge Q on the pail, according to the relation $Q = CV$, where C is the capacitance of the system. Therefore, voltage readings serve as a direct proxy for the magnitude and polarity of the charge.

- **Charging by Friction:** When two different materials are rubbed together, electrons are transferred from one to the other based on their electron affinity (triboelectric series). If the system is isolated, the net charge remains constant: $\sum Q_{initial} = \sum Q_{final}$.
- **Charging by Contact:** Touching a charged object to a conductor transfers charge directly. The conductor acquires the same sign of charge as the object.
- **Charging by Induction:** Bringing a charged object near a conductor causes charge separation. If the conductor is momentarily grounded, charges of the same sign are repelled to the ground, leaving the conductor with a net charge opposite to that of the external object.

2 Procedures and Methods

2.1 Apparatus

The experimental setup included a PASCO Faraday Ice Pail, a Wireless Charge Sensor connected via a clip cable, and charge producers (white and blue disks).

2.2 Experimental Procedure

2.2.1 Setup and Grounding

The charge sensor was connected to the pail (red clip) and the shield (black clip). Before each trial, the system was grounded by touching both the pail and the shield simultaneously to remove residual charge, and the sensor was zeroed in the Capstone software. The setup and grounding process are shown in Figure 1, 2.

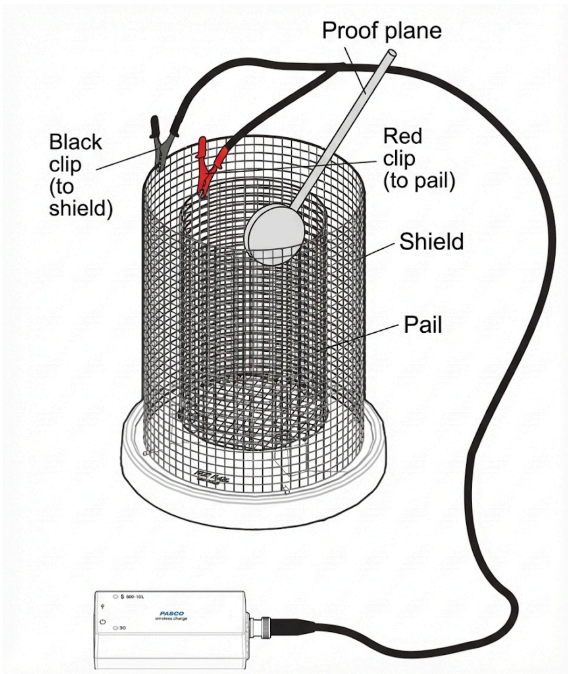

Figure 1. Experiment Setup

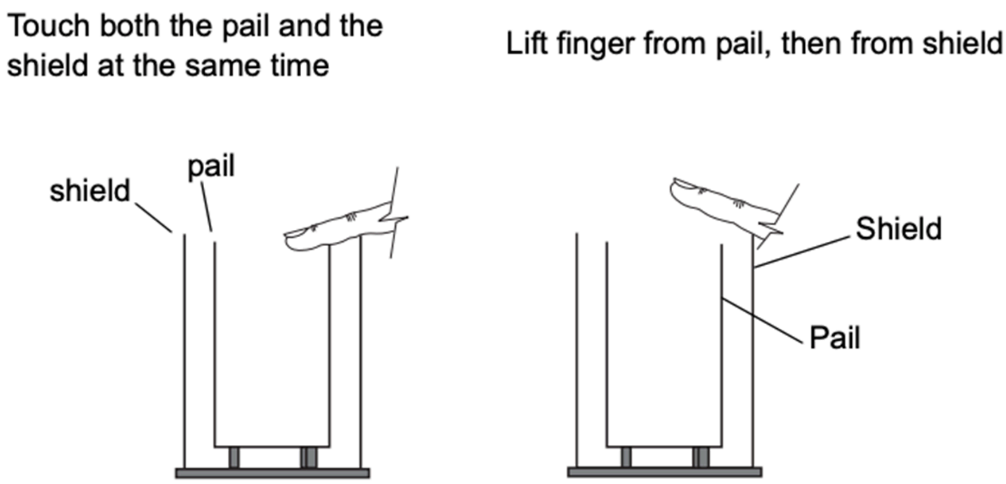

Figure 2. Ground the Ice Pail

Start by touching a single finger to the inner pail and the outer shield at the same time.
This will connect the inner pail to the grounded outer shield, thereby grounding both cylinders.

Once this is done, remove your finger from the inner pail while still in contact with the outer shield, then release contact with the outer shield.

2.2.2 Experiment 1: Charging by Friction

- **Trial 1a**

1. Ground the ice pail, zero the charge sensor, and discharge both charge producers.
2. Start data recording.
3. Hold one charge producer in each hand and insert both disks into the lower half of the ice pail. **(initial)**
4. Inside the ice pail, rub the charge producer surfaces together. **(after rub)**
5. Stop rubbing and separate the charge producers. **(after separation)**
6. Withdraw the blue disk. **(blue out)**
7. Insert the blue disk into the ice pail. **(both in)**
8. Withdraw the white disk. **(white out)**
9. Insert the white disk. **(final)**
10. Withdraw both disks. **(both out)**

- **Trial 1b**
  - Rub the charge producer surfaces together.
  - Discharge only the white charge producer by touching the disk to the shield while touching the shield with your other hand.
  - Repeat steps 2–10.
- **Trial 1c**
  - Rub the charge producer surfaces together.
  - Discharge only the blue charge producer by touching the disk to the shield while touching the shield with your other hand.
  - Repeat steps 2–10.

2.2.3 Experiment 2: Charging by Contact

- Trial 2a

1. Ground the ice pail, zero the charge sensor, and discharge both charge producers.
2. Start data recording. **(zero)**
3. Rub the charge producer surfaces together.
4. Insert the white disk into the ice pail (without touching it). **(initial)**
5. Let the disk momentarily touch the ice pail. **(after touch)**
6. Remove the white disk. **(disk out)**

- Trial 2b
  - Repeat steps 1–6 with the blue disk.

2.2.4 Experiment 3: Charging by Induction

- Trial 3a

1. Ground the ice pail, zero the charge sensor and discharge both charge producers.
2. Rub the charge producer surfaces together.
3. Start data recording. **(zero)**
4. Insert the white disk into the ice pail (without touching it). **(initial)**
5. While holding the disk in the ice pail, ground the ice pail by momentarily touching it with the lead attached to the shield. **(after grounding)**

6. Remove the white disk. **(disk out)**

- Trial 2b
  - Repeat steps 1–6 with the blue disk.

3 Data and Results

The raw data from the 3 experiments is presented below.

Table 1. Charging by Friction

Row	Description	Trial 1a (V) Both start neutral	Trial 1b (V) White starts neutral	Trial 1c (V) Blue starts neutral
1	Initial	0.003	-0.152	0.216
2	After rub	0.000	-0.153	0.213
3	After separation	0.001	-0.151	0.210
4	Blue out	0.349	0.046	0.366
5	Both in	-0.001	-0.152	0.211
6	White out	-0.335	-0.190	-0.139
7	Final	-0.005	-0.157	0.219
8	Both out	0.003	0.006	0.002
9	Sum of rows 4 and 6	0.014	-0.144	0.227

Table 2. Charging by Contact

Row	Description	Trial 2a (V) White Disk	Trial 2b (V) Blue Disk
1	Zero	-0.001	0.000
2	Initial	0.198	-0.117
3	After touch	0.212	-0.128
4	Disk out	0.206	-0.128

Table 3. Charging by Induction

Row	Description	Trial 3a (V) White Disk	Trial 3b (V) Blue Disk
1	Zero	0.001	0.004
2	Initial	0.152	-0.290
3	After grounding	0,001	-0.053
4	Disk out	-0.152	0.248

4 Discussions

4.1 Analysis of Charging by Friction

In Trial 1a (Table 1), the system started with zero net charge (Initial: 0.003 V). After rubbing and separating the disks inside the pail (Row 3), the voltage remained effectively zero (0.001 V), indicating that no net charge was created. When the blue disk was removed (Row 4), the pail measured the white disk's charge as **+0.349 V**. When the white disk was removed (Row 6), the pail measured the blue disk's charge as **-0.335 V**. The sum of these charges is $0.349 + (-0.335) = 0.014$ V, which is very close to zero. Generally, Sum of rows 4 and 6 for 1a, 1b, 1c are close to zero.

This confirms the **Law of Conservation of Charge**: the positive charge gained by the white disk is equal in magnitude to the negative charge gained by the blue disk.

Finding: The White Charge Producer becomes positively charged, and the Blue Charge Producer becomes negatively charged.

4.2 Analysis of Charging by Contact

In Experiment 2 (Table 2), I verified that contact transfers charge of the same polarity.

- **Trial 2a:** The white disk (positive) touched the pail. The final reading "Disk out" was **0.206 V** (positive).
- **Trial 2b:** The blue disk (negative) touched the pail. The final reading "Disk out" was **-0.128 V** (negative). This confirms that conduction transfers the specific charge of the object to the conductor.

4.3 Analysis of Charging by Induction

In Experiment 3 (Table 3), I utilized the principle of grounding to induce an opposite charge.

- **Trial 3a:** The white disk (positive, indicated by Initial +0.152 V) was inserted. The pail was grounded (reading goes to ~0 V). Upon removing the positive disk, the pail retained a **negative charge** (-0.152 V).
- **Trial 3b:** The blue disk (negative, indicated by Initial -0.290 V) was inserted. After grounding and removal, the pail retained a **positive charge** (+0.248 V). This demonstrates that charging by induction produces a charge on the conductor opposite to that of the inducing object. Interestingly, the magnitude of the induced charge (e.g., |-0.152|) was nearly identical to the initial detected charge (+0.152), suggesting a highly efficient induction process in the Faraday pail setup.

4.4 Sources of Error

- **Leakage Currents:** Charge can leak through moisture in the air or imperfect insulation, causing voltage drift over time.
- **Stray Charges:** The experimenter’s body or clothes may carry static charge, affecting the sensitive readings if they move too close to the pail.
- **Sensor Drift:** The "After grounding" values in Table 3 (e.g., -0.053 V for Trial 3b) suggest the sensor or grounding connection might not have been perfect, or the zero point drifted slightly.

5 Conclusion

This experiment successfully demonstrated the fundamental behavior of static electricity. I confirmed the conservation of charge by showing that friction generates equal and opposite charges on two neutral bodies (white became positive, blue became negative). We further validated that charging by contact results in the same charge polarity, while charging by induction results in the opposite polarity. The experimental data closely aligned with theoretical expectations, providing clear empirical evidence for the behavior of electric charges in conductors and insulators.