35 Coulomb's Law

Static Cling

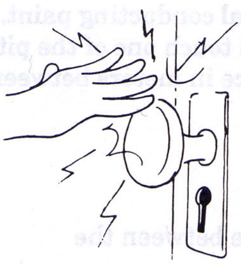
Purpose

To observe some of the effects of static electricity.

Required Equipment and Supplies

electroscope
conducting pith balls, non-conducting thread and stand
glass rods
fur
silk

Discussion



Have you ever been shocked when reaching for a door knob after walking on a carpet? Or found your sock hiding inside one of your shirts just after it came out of the clothes dryer? Or have you ever been caught in a lightning storm while back-packing? All of these situations arise due to *static electricity*. After this activity, you should understand its behavior a bit better.

Procedure

Part A: Charge on an Electroscope

Step 1. Make sure the electroscope is discharged (neutral) by touching the probe with your finger. The leaves will drop down. Do not open the electroscope in an effort to adjust the position of the leaves. NEVER touch the leaves. They are very fragile and far too delicate to be manipulated with fingers.

Step 2. Rub a hard rubber rod with fur, or a glass rod with silk. If you use the rubber rod, it will become negatively charged, while a glass rod will become positively charged. Touch the probe of the electroscope with the charged rod.

1. What happens to the leaves of the electroscope?

2. What kind of charge—relative to the rod—is on the leaves?

Step 3. Discharge the electroscope by touching the probe with your finger. Charge a hard rubber rod by rubbing with fur. Observe what happens to the leaves when you bring the rod close to (but not touching) the electroscope, and then move the rod away.

Step 4. Devise a way to charge the electroscope using the charged rubber rod, but *without touching the rod to the probe.* Write down your technique.

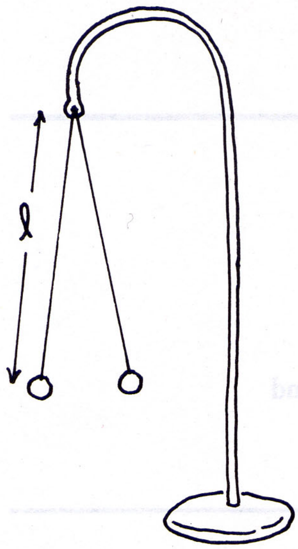


Figure 35.1

Part B: Charge on a Pith Ball

Step 5. Measure the mass of two identical pith balls and suspend them with non-conducting thread about 25 centimeters long as shown in Figure 35.1. Measure the length of the thread to the center of the pith ball.

length of the thread in meters, l = ________

mass of each pith ball in kg, m = ________

Step 6. The pith balls have been treated with a special conducting paint. Charge a hard rubber rod by stroking it vigorously and touch one of the pith balls. What happens to the balls? Measure the distance in meters between the two balls, r.

r = ________

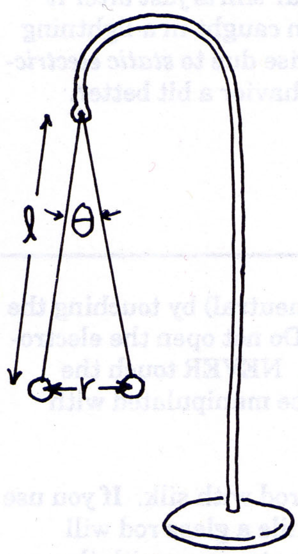


Figure 35.2

From your measurements of l and r, calculate the angle between the threads, θ, and the angle $\theta/2$ as shown in Figure 35.2.

θ = ________ $\theta/2$ = ________

Step 7. To calculate the amount of charge, q, on each of the pith balls, we need to analyze the forces acting on the ball when it is in equilibrium, as illustrated in Figure 35.3. The tension in the thread (neglecting the weight of the thread) is the vector sum of the ball's weight, mg, and the electrostatic repulsion, kq^2/r^2, as shown in Figure 35.4, where k is Coulomb's constant, $9 \times 10^9\ N \cdot m^2/C^2$. Solve for the distance between the two balls, r, in terms of the length of the thread, l, and $\theta/2$.

$\sin\theta/2$ = ________

Eq. (A) r = ________

Next, solve for the charge, q, on each ball by equating

$$\tan\frac{\theta}{2} = \frac{kq^2}{r^2} / mg$$

Eq. (B) q = ________

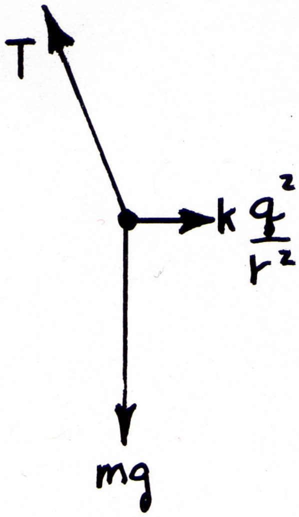


Figure 35.3

Step 8. Finally, eliminate the charge separation distance, *r*, from the equation (B) by using equation (A). Your final formula for the charge, *q*, will be in terms of all measured quantities *m*, *l*, *θ*/2, and the Coulomb constant, *k*.

q (formula) = ________

q (on pith ball) = ________ C

Analysis

3. How do environmental conditions affect the accumulation of static electricity?

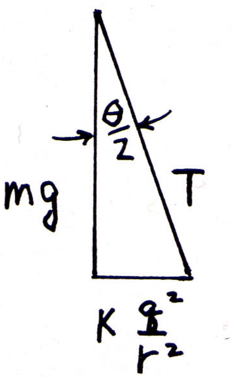


Figure 35.4

4. How significant is ignoring the mass of the thread of your calculations of the charge on the pith ball?

5. Devise a variation of this experiment to determine Coulomb's constant, *k*.