Electrostatics Module Student Guide

Activity 1: PhET Numerical Simulation [20 Minutes]

Open the Coulomb's Law PhET simulation which is located at https://phet.colorado.edu/en/simulation/coulombs-law . For today's Activity 1, click "Macro Scale".

A. Using this PhET simulation as your "experiment", determine from your observations what makes a force attractive or repulsive. Describe your experiments and observations with some examples.

B. What evidence in this simulation do you see that Newton's third law applies to electrostatic forces? Give an example based on your observations.

C. In the PhET simulation, how does the value of the electrostatic force seem to vary with the value of the charges? Give an example based on your observations.

D. In the PhET simulation, how does the value of the electrostatic force seem to vary with the distance between them? Give an example based on your observations.

E. Coulomb's equation is used for determining the force between 2 charged bodies separated by a distance:

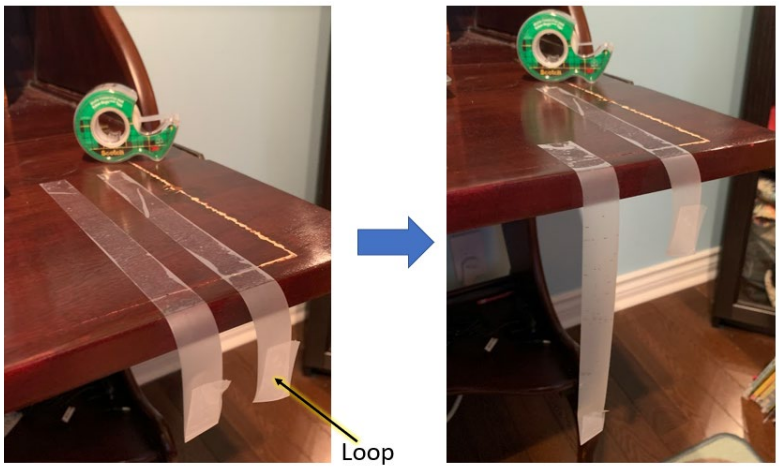
$$F = \frac{K|q_1||q_2|}{r^2}$$

The variables are K (Coulomb's constant), q_1 and q_2 (charges of bodies 1 and 2 in Coulombs, C), r (distance between the centers of the bodies in m), and F (electrostatic force in Newton, N)

Do a "measurement" on your PhET simulation of some particular values of q_1 , q_2 , r, and F to determine Coulomb's constant. Show your work and include an image of the "experiment" in your Google Slides. Verify your value with research and include a citation link.

Activity 2: Sticky Tape Experiment [20 Minutes]

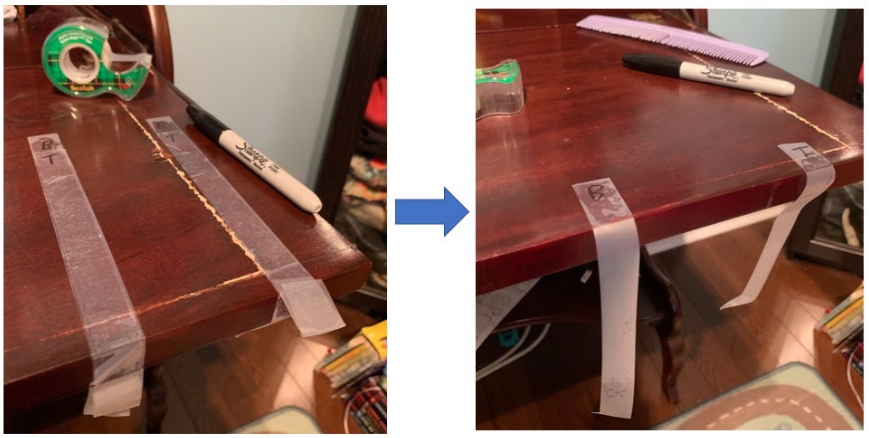
A. Press a length of sticky tape at least 20 – 30 cm long firmly on a table top or other unpainted surface, with a few cm hanging over the edge. Form a non-sticky handle by looping the tape hanging over the edge onto itself. Do this for a second length of sticky tape. Peel one of the tapes off the table and hang it from the edge of the tabletop or cupboard. Peel the second tape off the table and holding its handle bring it near the first tape. Try to keep your hand holding the second tape far away from the tapes that are hanging down. What happens? How does the distance between the tapes affect the interaction between them?



Fixed to the Table Surface

Hanging from the Edge of Table

B. Place two more strips of sticky tape on the surface as in Part A. Using a pencil or ball point pen or sharpie, mark the tapes with *B* for bottom. Press another strip of tape on top of each of the *B* strips; label these strips *T* for top.[1] Pull one pair of strips off the surface, separate them, and hang them from the edge of the tabletop or cupboard at least 50 cm away from each other. Pull the second pair of strips off the surface and separate them. Describe the interactions between the T you are holding and the T and B hanging off the table. Describe the interactions between the B you are holding and the T and B hanging off the table. Caution: if the two tapes come into contact with each other the charges on them may change. Based on your observations, what can you say about the signs of the charges on the B and T strips?



"T" is on top of "B"

C. Rub or comb a plastic comb through the hair or fur of a mammal (a human, cat or dog will do). Hold the comb horizontally and bring it near but not touching the hanging bottom and top strips. Describe what you observe. Caution: if the tape touches the comb the charge on the tape can change.

D. Following Benjamin Franklin, we arbitrarily call the charge on the plastic comb after being rubbed by mammal fur or hair *negative*. [And if you take a glass rod and rub it with silk, the glass tends to obtain a positive charge.] For the sticky tape, what type of charge is on the top strip? What type of charge is on the bottom strip?

Activity 3: Balloon Experiment [25 Minutes]

Blow up two balloons, tie them off, and tie each to the end of a string that is about 1 m long. Hang each balloon from something, so they are hanging next to each other. Rub both of the balloons on mammal fur or hair. You will be assuming the balloons have the same amount of charge each, so try to rub them both the same amount. When they are hanging next to each other, they should repel one another. Take a photo of the situation, and measure the angle that the strings make with each other. You may be able to find an app on your phone which measures angles. Measure the distance between the centers of the balloons. Estimate the mass of each balloon. From your measurements, estimate the charge on each balloon.

[Please include an approximate uncertainty in your calculations, based on the largest fractional uncertainty of input measurements. For example, assume your largest fractional uncertainty is that of the mass of the balloon which you estimate to be (4 ± 1) g. This is a fractional uncertainty of ¼ = 25%. So the uncertainty in your final charge estimate should be ¼ of the value you estimate for the charge.]