# Experiment 1: Coulomb's Law

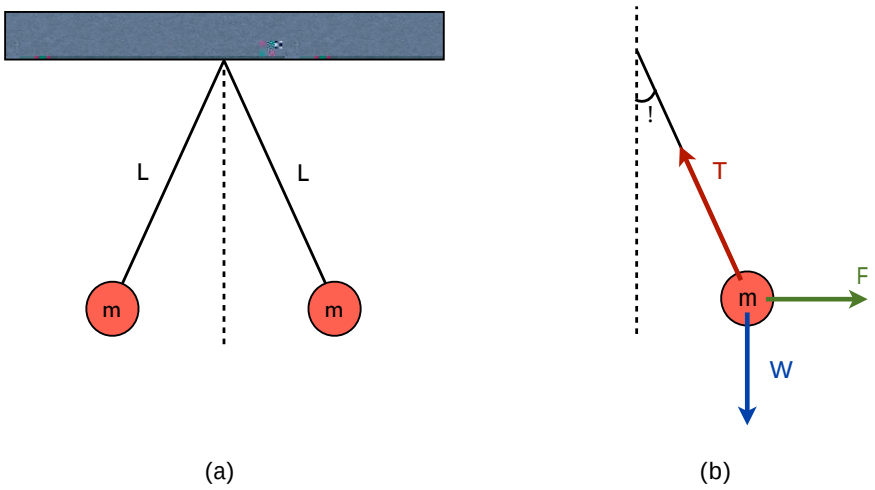
## Introduction to Coulomb's Law

In 1785 Augustin de Coulomb investigated the attractive and repulsive forces between charged objects, experimentally formulating what is now referred to as Coulomb's Law: \The magnitude of the electric force that a particle exerts on another is directly proportional to the product of their charges and inversely proportional to the square of the distance between them." Mathematically, the magnitude of this electrostatic force $F$ acting on two charged particles $(q_1; q_2)$ is expressed as:

$$F = k\frac{q_1 q_2}{r^2} \tag{1}$$

where $r$ is the separation distance between the objects and $k$ is a constant of proportionality, called the Coulomb constant, $k = 9{:}0 \quad 10^9\ N m^2{=}C^2$. This formula gives us the 21l [(N)-0-346(of)-7.935 635.68(of)-7he 68(of)

In this lab, we will study Coulomb's law and measure the electric charge transferred from one object to another using a pith ball electroscope. A simple electroscope is a device used to measure the presence and magnitude of electric charges. The pith ball electroscope in Figure 1b, for example, shows the attraction between two charged objects - a pith ball (a light weight object that can easily be charged) and a charged rod. There are two ways to displace charges an object: conduction or induction. Charging by conduction involves direct contact while induction requires no contact. Rubbing dissimilar materials, for example, can remove or deposit electrons. This is process is referred to as triboelectricity (or frictional electricity) since the materials are charged by friction. For example, rubbing a neutral glass rod with silk \rips" charges o one of these surfaces and makes them stick to the other. Whether a material is an electron donor or




(a) (b)

Figure 3: (a) A simple electroscope with two equally charged objects of mass \m" hanging from threads of length L. (b) Free body diagram for the right pith ball.

## Experimental Procedure:

In this lab you are given colored pith balls each with a mass of 0.04 grams. You also several types of conduction rods as shown in gure 2. Use the following materials to triboelectrically charge the rods: wool/felt, silk, plastic bag sheet (polyethylene), your own hair, and mystery fur. Charge the pith balls by dragging the rod across the metal support where the string is tied. Avoid touching the pith balls or support with your hand (that will discharge the balls). Note that once the pith balls are charged they will slowly (or quickly, if it's humid) start to discharge. A mirror scale is provided to measure the separation distance \r" . If the pith balls discharge too quicky, both lab partners should estimate a value forthe distance.

Using the pith balls, devise and carry out an experiment to measure the amount of charge transferred to each pith ball by the rods and the Coulomb force between them. Repeat the experiment with di erent rods charged by di erent materials.

Knowing that the acrylic rod acquires a positive charge when rubbed with silk, devise an experiment to conclude what kind of charge ( ) the other rods obtain when rubbed with silk. Repeat this for plastic, wool or mystery fur.

Answer the following questions in your lab write up:

1. Using the free body diagrams of Figure 3, derive an expression for the charge in terms of the pith ball mass *m*, and the separation distance \r".
2. Calculate the charge on the pith balls for each rod/soft material combination. How many millions or billions of electrons reside on each pith ball?
3. Compare the extremely small gravitational attraction between the two pith balls with the repulsion of the electrostatic force.
4. Develop a way to determin if the mystery fur is from a rabbit or cat. If you have time, try your method out, to see if it works. If time is short, or humidity is too high, describe how one could carry out the method in conditions with lower humidity.