The Force Between Two Charged Spheres

Introduction

In this lab we investigate how the magnitude of the repulsive force between two similarly charged objects depends on the distance between the objects. We might expect that the force gets weaker as the distance increases, and gets stronger as the distance decreases. Coulomb's Law describes the mathematical relationship between force and distance for two *point* charges. In this experiment we will determine how the force between two similarly prepared, charged pith balls depends on the distance between their centers. We will assume that the force varies as $F = Cr^n$, in which r is the distance between the centers of the pith balls, and determine n.

The photo below shows two silver pith balls inside a wooden box. The right-hand pith ball is suspended by a light string, barely visible in the photo. The left-hand pith ball is mounted on the end of a long insulating rod attached to a wooden block seen to the left of the box. When the balls are similarly prepared, as shown, the pith ball on the left exerts a force F on the hanging pith ball, pushing it to the right by an amount x. By moving the wooden block, we can vary r, the distance between the balls, and see how x is affected.

Also visible in the photo are a ruler and a mirror. The ruler is used to accurately measure the position of each pith ball, and the mirror is used to eliminate parallax errors, as will be explained in lab.

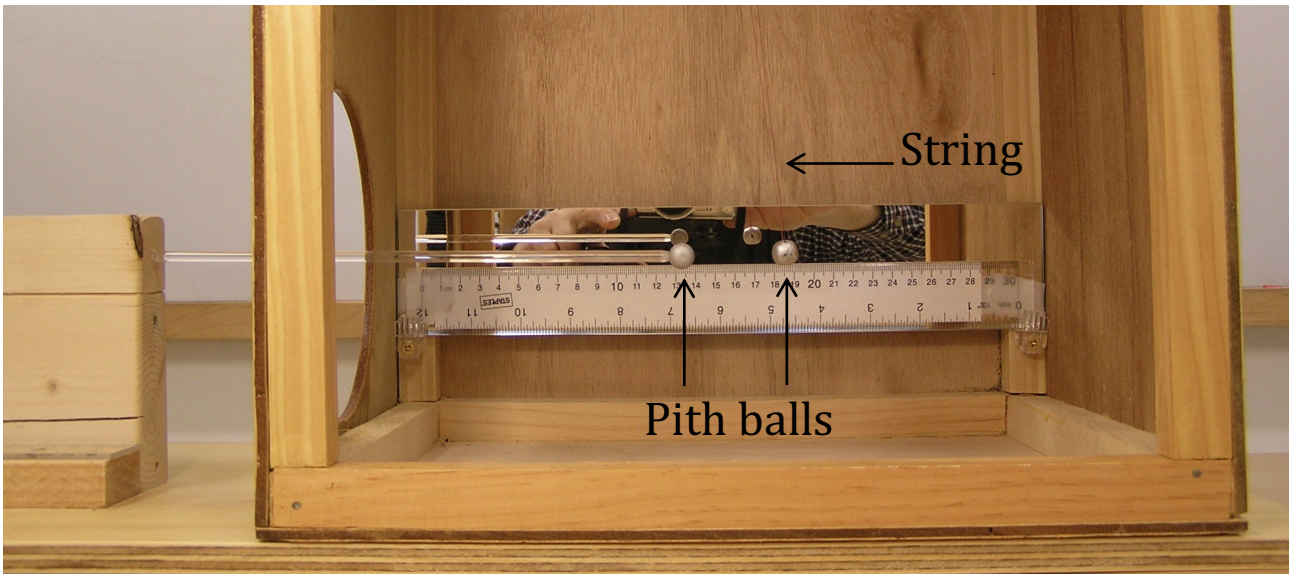


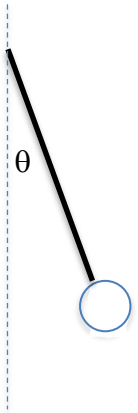
Fig. 1: The pith ball on the left exerts a force, F, on the hanging pith ball, causing it to be displaced from the vertical.

Prelab

1. One of your classmates took the following data for period (T) vs mass (m) of a vertically oscillating spring system. Use a log-log plot to determine the exponent in the relationship between m and T with uncertainty. Submit your plot with the exponent value given in standard form.

Period (s)	Mass (g)
0.765	100
0.921	150
1.060	200
1.386	350
1.479	400

2. To measure wind speed, a sphere hanging on a string is suspended in a stream of air. Assuming the wind speed is steady and directed to the right, the force due to the wind will deflect the ball by an angle θ, as shown on the figure below. The mass of the sphere is m and the length of the string is L.



   a. Draw the free body diagram for the situation pictured.

   b. Determine an algebraic expression for the tension force applied to the string.

   c. Determine a simplified, algebraic expression for the force due to the wind.

Procedure

1. Explore the apparatus to see how it works.

2. Charge the rod by rubbing it with the wool cloth. To charge the hanging pith ball, touch it with the charged rod. The pith ball will probably be attracted at first, but once charge transfers from the rod to the pith ball it will be repelled. Charge the rod again by rubbing with the cloth and touch it to the mounted pith ball.

3. To see how the charge affects the system, move the wooden block towards and away from the hanging pith ball and note the effect.

4. With this background, work with your partner(s) to come up with an initial procedure to measure the distance dependence of the force. Your procedure should contain at least: a schematic, a free body diagram, the relevant force analysis, a method for collecting the necessary data, and the preferred method of graphing your data. This is your first draft of the procedure.

5. Re-charge the two pith balls. Start taking data!

6. At some point call the instructor over to discuss your method. You might wish to refine your procedure and take more data. In your notebook, you must be sure to discuss your final procedure.

7. Determine the power of r, i.e. n, including uncertainty and quoting your result in standard form. Discuss your result in terms of what you expected and in terms of random and systematic errors.