Name _____ School _____ Date _____

Electric Fields and Potential Difference between Parallel Plates

Purpose

To observe the effect of the electrostatic force on light-weight charged objects in a uniform electric field
To experimentally determine magnitude of the electric field between two oppositely charged parallel plates
To experimentally determine the electric potential difference between two oppositely charged parallel plates

Equipment

Virtual Electrostatics Lab PENCIL

Explore the Apparatus/Theory

Open the Virtual Electrostatics Lab.

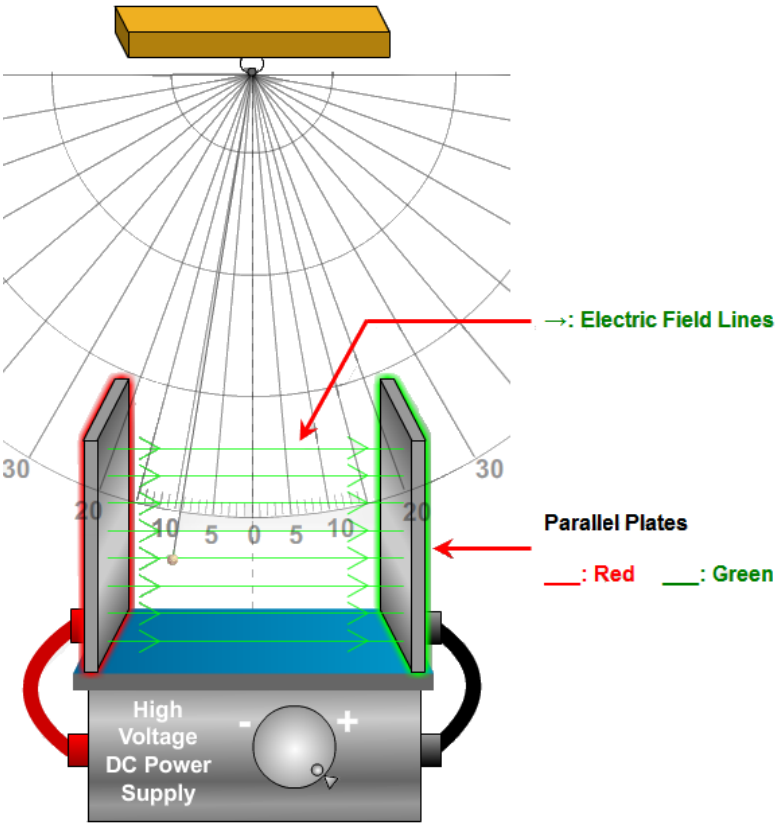

Figure 1

This lab and the Coulomb's Law lab use parts of the same apparatus. The Coulomb's Law documentation explains how part of the apparatus is used. That explanation will not be repeated here and much of what is learned from that lab is directly applicable to this lab. It will be assumed that you have already completed the Coulomb's Law lab before starting this one.

Just as in the Coulomb's Law lab, you will not be given detailed instructions for how to perform this lab. Instead you'll be given some specific tasks to perform and will need to devise and explain your own procedure.

There's just one new piece of apparatus to examine. A high voltage DC power supply is used to give equal, but opposite charges to a pair of parallel plates. We'll assume that the plates are large enough and close enough together to provide a constant electric field in the region occupied by the pith ball. That field is represented by green arrows directed either to the right or the left when the plates are charged. The magnitude of the field is indicated by the brightness of the arrows.

Let's investigate this new environment. Charge up the pith balls with the charging rod as you did in the Coulomb's Law lab. Use a large charge, charge # ≥ 100. Move your pointer over the strings near where they're attached at the top. When your pointer changes to a hand (or whatever) click and drag a single pith ball pendulum and release it over the identical attachment hook above the parallel plates. (This can be a bit tricky. Just be patient. If all else fails, just restart.)

The power supply voltage is controlled by a knob that rotates through about 270 degrees. At each extreme, the dot on the knob matches up with one of the markers on the body of the voltage supply. Click on the knob and drag it clockwise and counterclockwise. Notice how the electric field lines behave as you rotate the dial.

1. When the knob is rotated fully **counterclockwise**, the direction of the **force on the pith ball** is

   a) to the left. b) to the right. (Circle one)

2. and the direction of the **electric field between the plates** is

   a) to the left. b) to the right. (Circle one)

3. Thus the **sign of the red plate** is a) positive. b) negative.

4. When the knob is rotated fully **clockwise**, the direction of the **force on the pith ball** is

   a) to the left. b) to the right. (Circle one)

5. and the direction of the **electric field between the plates** is

   a) to the left. b) to the right. (Circle one)

6. Thus the **sign of the red plate** is a) positive. b) negative.

7. The **sign of the charge on the pith ball** is a) positive. b) negative.

8. Explain your reasoning for #7.

Finding the maximum force, F on the pith ball, the electric field magnitude, E, and the potential difference, V, between the plates

As you have observed, as the voltage of the power supply changes, the magnitude of the electric field between the plates changes, resulting in a change in the magnitude of the force on the pith ball. Working backward, finding the force will allow you to find the electric field which will then allow you to find the potential difference between the plates.
$F_{e\,max} \rightarrow E_{max} \rightarrow \Delta V_{max}$. That is your goal.

- If you haven't done it already, charge up the pith balls and drag one over to the attachment ring on the left. Use a large charge for best results, charge # ≥ 100. Record the value of the charge given in the info box in Table 1.
- The values for $F_{e\,max}$, E_{max}, and ΔV_{max} could be found by deflecting the ball **all the way** right or left.
  For clarity's sake, adjust the voltage so as to deflect the ball all the way to the right in your investigation.
- The forces involved are gravity (weight), W, the string tension, T, and the electrostatic force, F_e. Forces that are not horizontal or vertical will need to be resolved into correctly-labeled components.
- Record any data you take in the data table provided. You may add additional information to the table.
- Explain your method in words, **referring to labeled figures which you supply**. (Space is provided below.)
- Clearly show your calculations using the proper variable terminology. Define any variables that you create.
  E.g., F_e: electrostatic force on the pith ball.

Table 1 Pith Ball between Parallel Plates (you may not actually use all of these values)

$k = 9.0\times10^9$ N m^2/C^2 g = 9.8 N/kg charge # = ____

mass of a pith ball, m = _____ kg

charge on one pith ball, Q = _____ C

plate separation (found with ruler), d = _____ m
Measure at the front edge of the plates – the edge closest to you.

length of the pendulum (tie-off point to center of pith ball), L = _____ m

horizontal deflection distance of the ball (dotted center line to center of pith ball), x = _____ m

deflection angle of a pith ball from the vertical in either direction, θ = _____ °

9. In the space below explain, in words, your method for determining the **magnitude of the electrostatic force on the pith ball, F_e,. Refer to labeled figures.** (You supply the figures.)

10. Clearly show your calculations using the proper variable terminology.

11. In the space below explain below, in words, your method for determining the **magnitude of the maximum electric field between the plates and the magnitude of the maximum potential difference between the plates.**

12. Clearly show your calculations using the proper variable terminology.

13. Each plate is an equipotential plane. In Figure 2, three additional equipotential **planes** have been added between the plates including one seen edge-on at the center. The potential at the center plane is zero kV. Label the potential at each of the other four equipotential planes in kV.

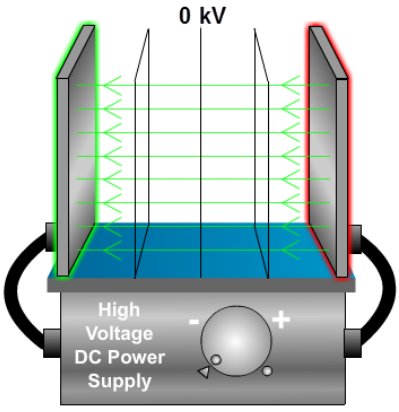

Figure 2