PHY1033C **Fall 2017**

Laboratory 4
Electrostatics

In this experiment you will explore various aspects of electrostatic charging and electrostatic forces as we discussed and demonstrated in lecture. The physics law involved in this experiment is Coulomb's law:

$$F_C = k\frac{qQ}{r^2}.$$

You are probably aware of various phenomena associated with static electricity or static charge. Some of the more familiar examples include: rubbing a balloon in your hair and sticking it to a wall, getting a shock when you walk on a carpet and touch a doorknob, or the sticking together of clothes taken from a dryer. Living in Florida, we are usually spared the more severe effects of static charge. Ordinary matter is composed of atoms of the various elements. An atom is composed of a heavy positively charged nucleus and light negatively charged electrons. There is a perfect balance in charge which makes an atom electrically neutral. Therefore, normally matter is uncharged. However, electrons are fairly mobile and quite a few can be removed from or added to a material by simple rubbing. As the number of electrons added or removed increases, further charging becomes more difficult. Because the force between charges is so strong, effects such as attraction and repulsion can be quite noticeable even if only a very small fraction of the atoms in a material gain or lose electrons.

The pie plate experimental set-up is illustrated in the picture below. The set-up is composed of a set of Plexiglas (insulator) cylinder ring and plate, and an aluminum (conductor) pie plate with a white PVC (insulator) tube at the center. There are also two black tapes and a small light bulb electrically attached on the rim. **Before you set up this, the first thing to do is to charge the Plexiglas plate by rubbing**

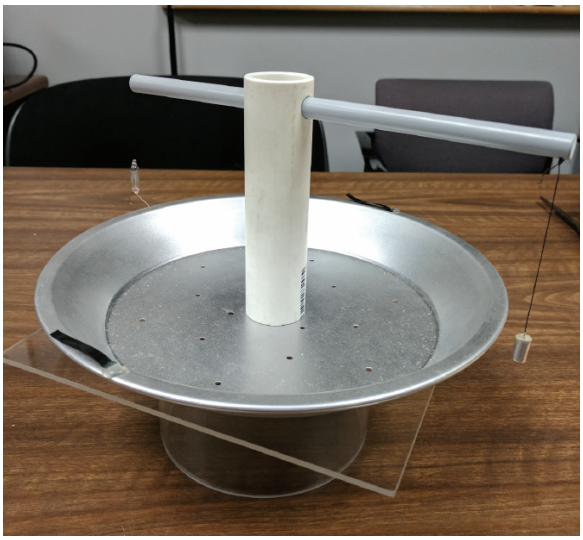

FIG. 1: Experimental setup of the pie plate demonstration

the plate with a bunch of paper towel. The Plexiglas may need to be recharged from time to time if necessary. The aluminum pie plate is a conductor and should be handled by the PVC tube so that it does not become neutralized through conduction. In the instructions to follow, **always hold, place, lift, or lower the pie plate by the PVC tube**. *In this lab there are no quantitative measurements. But you have to describe your observation in detail and provide your reasoning based on the physics discussed.*

1. Charge the Plexiglas plate and place it on top of the cylinder. Make sure that the pie plate is uncharged by touching it directly with your finger. Then, place the pie plate on top of the Plexiglas (hold the PVC tube!). Observe that the cassette tape rises. The tape is a flexible conductor and the glued end remains in contact with the pie plate. Thus, when the rim of the plate becomes charged (positively or negatively), the tape also gets a like charge and the repulsion between them makes the tape go up. Note that the tape going up only indicates there is charge on the rim of the pie plate; it does not provide the sign of that charge or tell whether or not there is charge on the base of the pie plate.

2. Lift the plate off the Plexiglas. The tape may go up, but don't worry about that now. We will explore that a bit later. (a) For now, simply touch the plate while it is off the Plexiglas to neutralize it and make the tape drop. (b) Place the pie plate back on the Plexiglas. The tape should rise again. (c) With the tape still up, lift the pie plate off the Plexiglas. The tape should fall. (d) Repeat the lowering and raising of the pie plate to see that the tape rises when the pie plate is on the Plexiglas and falls when it is off the Plexiglas.

3. At each step (a)-(c), give an explanation for what happens. In particular, describe whether any charge moves on or off the pie plate, whether charge rearranges itself within the pie plate, whether the rim of the pie plate or its base or both have charge, whether there is a net charge on the plate overall, and give the signs of the (rim, base, and net) charges. Hint: think about what happens to the electrons in the pie plate in the presence of the positively charged Plexiglas.

4. Charge the Plexiglas and holding the pie plate away from the Plexiglas, neutralize the plate by touching it. (a) Place the pie plate on the Plexiglas. The tape should go up. (b) With the pie plate on the Plexiglas and the tape still up, touch the pie plate with your finger. The tape should fall. (c) Lift the plate quickly and the tape should now rise up. (d) With the plate up in the air and the tape indicating a rim charge, lower the plate onto the Plexiglas. The tape should fall.

5. At each step (a)-(d), give an explanation for what happens. In particular, describe whether any charge moves on or off the pie plate, whether charge rearranges itself within the pie plate, whether the rim of the pie plate or its base or both have charge, whether there is a net charge on the plate overall.

Neat Demonstration

6. Investigate carefully the light bulb at the front of the classroom. The light bulb has two rod-like electrodes inside, one connected to each wire coming out of the bulb. Think of the power supply as a source of charge positive charge from the positive (red)

terminal, negative charge from the negative (black) terminal. The light from the bulb emanates from around only one of the electrodes. Is the lit electrode connected to the positive or the negative side of the power supply? Swap the connections to the bulb. Which side lights now? Now you can use this to determine the type of charge on the pie plate.

7. Dim the room lights. Neutralize the plate and put it back on the charged Plexiglas. With the tape up and indicating a charged rim, touch the free wire of the light bulb while watching the electrodes inside the bulb. The light produced may be weak so you may have to shadow the bulb to see it. Then repeat the experiment 4(a) - (c) and then touch the free wire of the bulb. For each case (on or off the Plexiglas), state whether the light emanates from the electrode connected to the free wire or from the electrode attached to the rim. Based on the results of the previous step, determine the sign of the charge on the rim in Steps 2 and 4.

8 (**Optional**) If you have time, set up your charge pie plate on the cylinder and adjust the position of the pendulum at the rim level and about 1 in away from the rim. Nudge the pendulum with your finger and keep your finger near the original pendulum position. Observe what kind of motion the pendulum performs. What causes this?