Electrostatics and uncertainty from experimenter

Objectives:

1. Produce, transfer, and measure static charges
2. Analyze uncertainty caused by experimenter

Introduction

Positive static charges are generated on the surface of a conductive sphere (the globe) by an electrostatic voltage source. A metal proof plane (the wand) putting in contact with the globe transfers charges on the wand. The wand then is inserted into a Faraday pail to measure the amount of charges through a charge sensor and the value is recorded in PASCO software (Capstone).

The user's manual of the equipment is posted on Blackboard with the relevant sections highlighted.

Note: This experiment is very sensitive to static charges around the measuring equipment and all charge carrying surface (the globe and wand) should be kept clean. Before setting up the experiment, make sure,

1. You ground yourself. This is done by wearing a wristband plug into either the Com (black) port on the voltage source or the ground port installed on your experiment table.
2. Wear a glove. Do not touch the surface of the globe or the wand with bare hands.

Charge production

Charge the globe with the voltage source using a cable: the banana plug to the +2000V port on the voltage source and the alligator clip to the screw knob on the globe. Make sure the connections are tight on both end. You can find correct connection in the right-hand-side figure on page 1 in the user's manual. Plug in the DC adaptor to 110V installed on the lab table and turn the voltage source on.

Questions to consider: How do the charges distribute on the globe? What determine the total charges, and charge density?

Put the surface of the wand in tangent to the surface of the globe as shown in the first figure on page 2 of user's manual. This will ensure both surfaces have the same charge density

so that the amount of charge on the wand is proportional to the amount on the globe. Figure 1(a) shows the full setup for charge production.

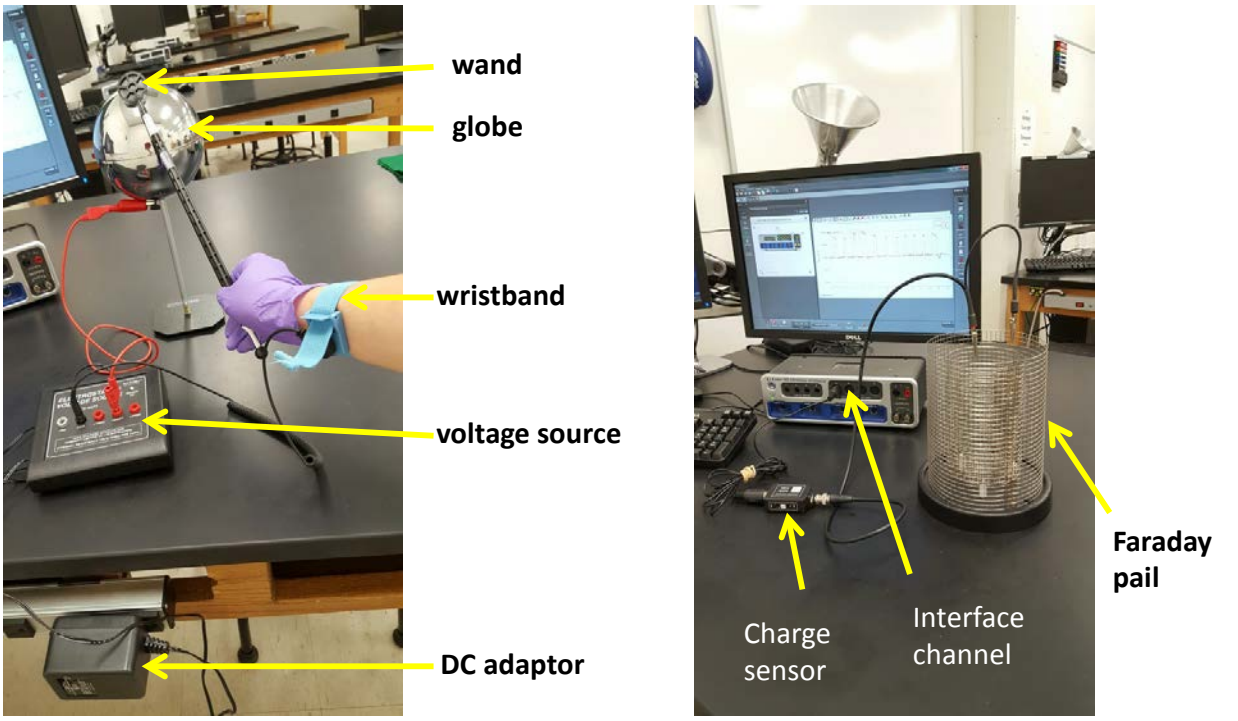

Figure 1. setup for charge production (a) and measurement (b).

Charge measurement

The measurement equipment (as shown in figure 1(b)) consists of a Faraday pail connected to a charge sensor that is plugged in to one of the channels on PASCO interface. The result is read out from PASCO Capstone installed on the desktop of the lab computer.

The principle of operation is shown in Figure 2. The outer cylinder of the Faraday is grounded at all time. The inner cylinder should have no net charge initially when the wand is far away. Press the zero button on the charge sensor right before bringing the wand close to the pail. This should discharge any residual charges from previous measurements. The net positive charges on the wand head inside the pail will hold negative charges on the inner cylinder while the same amount positive charges moving through the charge sensor. The amount of positive

charges registered on the sensor depends on the amount and position of charges on the wand head. Make sure the wand head is placed near the bottom of the pail, but does not touch any parts of the pail. For repetitive measurement, try to place the wand head to the same place in the pail. Use "x1 gain" on the sensor

Note: keep the globe away from the Faraday pail as far as possible during the measurement.

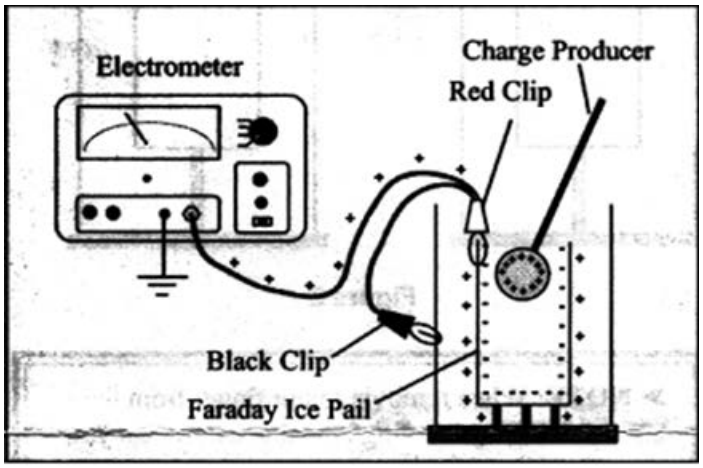

Figure 2. Measure charges with Faraday pail. Electrometer is replaced by a charge sensor in our lab.

Settings on Capstone (shown in figure 3)

1. Open Capstone from desktop
2. Add charge sensor to hardware, set gain in the software to x100
3. Hit the "record" button, press "zero" on the charge sensor, bring in the wand and insert into the Faraday pail carefully, and hold it steady for a few seconds, then remove the wand.
4. Read the charge peak value either using software tool that read the maximum or coordinates.

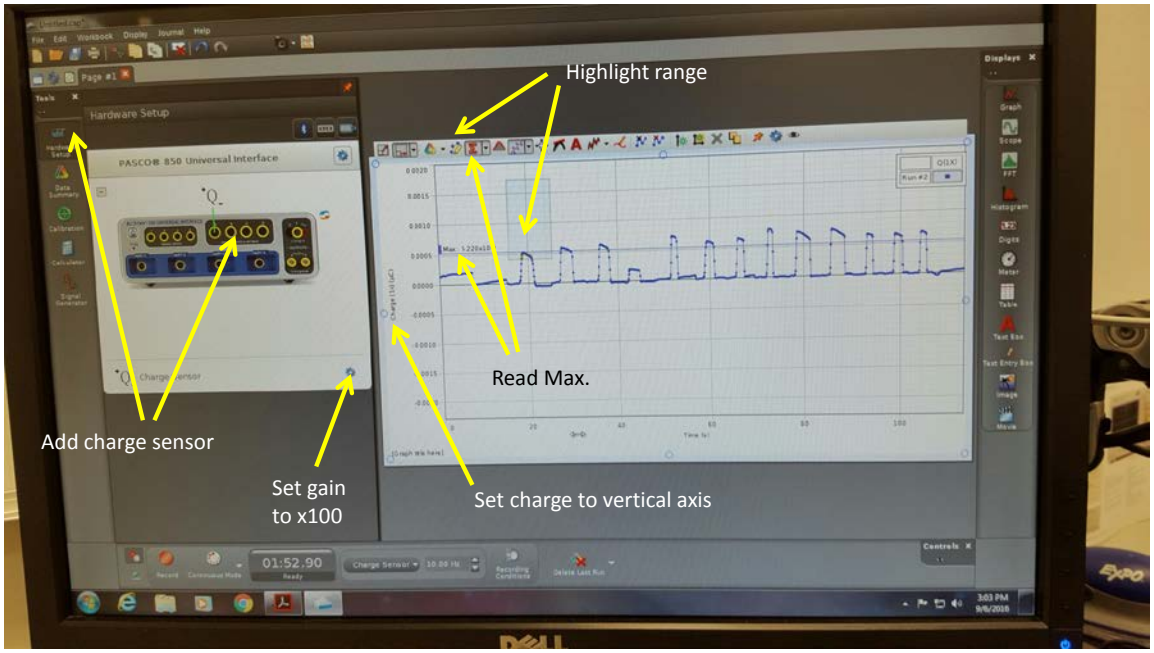

Figure 3 Capstone setting and readout of charge value.

Experiment:

1. Every student collects a set of 15 data point by repeating the measurement 15 times. Record your team's data sets in the excel file. Calculate the average and standard deviation of each individual set.
2. Apply "frequency" function to each individual data set. Plot histograms of frequency vs charge of your team's data sets.(Refer to the excel file used in week1 for correct use of "frequency" function). In your team's abstract, address the following questions. Cite values to support your statements.

   a). Do the measured values agree? If they do or don't , what may be the reason?

   b). Which data set is more (and less) precise? What may be the cause?