Physics Exploration Homework Supplement **P111-9.pdf**

Faraday Ice Pail: Exploring Gauss's Law and Shielding

These activities will improve your conceptual understanding if you predict the outcome you expect at each step below BEFORE performing the activities.

Go to the Physics Exploration Center. Enter through the resource room in 311/312 Thaw Hall. Go to the setup which consists of a Faraday cup (or pail), electroscope, a metal sphere on an insulating rod (for holding), an electrophorus (insulating surface and metal plate with insulating handle) and small Styrofoam (insulator) pieces hanging on thin thread.

Important: Before you start the experiment, discharge everything mentioned above by touching it with your hand or the ground wire.

(a) Charge the metal plate (electrophorus) by using the procedure used in the last exploration as follows: Rub the insulating surface with the fur vigorously. Negative charges appear on the insulating surface. Now put the metal plate (which has an insulating handle) on the insulating surface that you just "charged" by rubbing with fur. Charge separation will take place on the surface of the metal plate by induction due to its proximity with the insulating surface. Now ground the metal plate to create net charge on it. You could ground the metal plate by touching with your fingers while the plate is still on the insulating surface. However, it is preferable to touch the metal plate with the grounding wire provided with the setup to avoid getting shocked. <u>Then, remove your fingers or the grounding wire</u> (whichever you used). Then, lift the metal plate by holding it with the insulating handle.

(b) Now touch the charged metal plate with the metal sphere by holding the sphere by the far end of the insulating handle to avoid the metal sphere from being discharged (We need to have lots of charge on the metal sphere!).

(c) Predict and draw the charge distribution on the outside and inside surface of the Faraday pail and also the electric field lines inside and outside the pail AFTER you insert the charged metal sphere inside the Faraday pail <u>without touching</u> the pail's surface. Do you expect the effect of the charged metal sphere inside the pail to be felt outside the pail in someway? Why or why not? Now perform the experiment by bringing down the charged metal sphere in the pail carefully from above the pail ensuring that the sphere DOES NOT touch the surface of the pail. Do you see any deflection in the nearby electroscope? Explain what you observe using what you learned in class and reconcile any differences between your earlier predictions and observations.

(d) If you carefully take out the charged metal sphere from the pail (without touching the pail) and take the sphere far from the electroscope, will the electroscope still show a deflection? Explain. Perform the experiment by carefully removing the sphere from the pail. Explain any discrepancies in your prediction and observation.

(e) Predict and draw the charge distribution on the outside and inside surface of the Faraday pail and also the electric field lines inside and outside the pail AFTER you insert the charged metal sphere inside the Faraday pail and touch the pail's surface with it. Now perform the experiment by touching the inside of the pail with charged sphere and note any deflections in the nearby electroscope. Predict what would happen to the electroscope deflection if you take out the charged metal sphere from the pail and take the sphere far from the electroscope? Explain. Perform the experiment by removing the sphere from the pail. Explain any discrepancies in your prediction and observation.

(f) Now un-charge only the metal sphere by holding it with your hands. Then, bring this uncharged sphere inside the pail (whose inside you had earlier touched with the charged sphere). Touch the uncharged metal sphere with the inside surface of the conductor. Predict if you expect to have a net charge on the metal sphere after this? Now check your prediction by taking out the metal sphere from the pail and bringing it close to a gold leaf electroscope (this electroscope is more sensitive and can detect presence of small charge on objects). Do you see any deflection? Explain any discrepancies in your prediction and observation.

(g) Predict how the results in part (f) would be different if we touch the uncharged metal sphere to the outside surface of the pail instead of the inside surface. Perform the experiment and check for deflection in the electroscope. Explain any discrepancies in your prediction and observation.

(h) Predict what would happen if you brought an uncharged Styrofoam piece hanging on a thread INSIDE the pail (not touching the pail) and brought a charged object e.g., a charged metal plate of electrophorus close to the OUTSIDE of the pail (not touching). Draw and diagram showing the charge distribution. Perform the experiment and check for any deflection in the Styrofoam (which is inside the pail) due to the charged metal plate outside the pail. Explain any discrepancies in your prediction and observation.

(i) If you put the uncharged Styrofoam piece OUTSIDE the pail (not touching the pail) and a CHARGED metal sphere INSIDE the pail (but NOT touching the pail), you should see a deflection in the uncharged Styrofoam piece if there is sufficient charge on the metal sphere. Draw a diagram showing why the Styrofoam should feel a net electric force and explain whether it is attractive or repulsive. Perform the experiment making sure there is sufficient charge on the metal sphere (to ensure that you have put sufficient charge on the metal sphere, make sure the electroscope connected to the outer surface deflects when you put the sphere inside the pail). Explain why there is a difference in what happens to the uncharged Styrofoam in this case as compared to the trial in part (h).