**Introduction**

These lab activities will focus on the concepts of charge interactions and charge transfer. You will create a model of charge based on your experimental observations. You should read all the steps in each part before you start and work in groups. Make sure you read Serway & Faughn sections 15.1 & 15.2.

**Pre-Lab Questions:**

1. *A thin stream of water bends toward a negatively charged object. What will happen to the same stream of water when a positively charged object is placed near it? Explain.*

2. *Warm air can hold more moisture than cold air. The higher moisture content of air makes it a better conductor of electricity. Would you expect the shocks from static electricity to be more severe in summer or winter? Explain.*

3. *Two charged pith balls are suspended on very light 12.0 cm strings. Each has a mass of 10.0 g. In equilibrium, the total angle between the strings is 50.0°. Draw a free-body diagram for one of the pith balls and clearly label all forces with magnitude and direction. Assuming the pith balls are equally charged, what is the charge on each ball? (This is not a qualitative prediction; a numerical answer must be obtained.)*

**Part A – Charge:**

A1. You and your partner should each press a 10 cm long piece of tape sticky side down on the lab bench, with one end curled over as a non-stick handle. Peel the tape off the table and bring the non-sticky side of the tape toward your partner’s strip. What happens as the tapes get closer together?

A2. Place two strips of tape on the table sticky side down with a non-stick handle and label then “B” for Bottom. Press another tape (with a non-stick handle) on top of each of the “B” pieces; label these strips “T” for top. Pull each pair of strips off the table. Then pull Top and Bottom strips apart.
   - Describe the interaction between two Bottom strips.
   - Describe the interaction between two Top strips.
   - Describe the interaction between a Top and a Bottom strip.

A3. We say that the tapes are “charged”. Based only on the experiments you did in A2, answer the following questions:
   - Do the experiments in A2 provide evidence of the number of types of charges that exist? Explain your reasoning. If so, for how many types of charge do you have evidence? Explain.
   - Do you have sufficient evidence (based on your experiments only) to determine the number of types of charge that exist? Could there be more or less charges than in your answer you gave in the previous question?
If so, explain in detail why the evidence you have is sufficient to determine the number of types of charge that exist and why no further experiments are needed.

If not, explain why the experiments in A2 are insufficient. Are there further experiments that need to be done in order to determine the number of types of charges that exist? If so, what experiments would you do? Explain how these experiments would determine if the number of types of charge you found is the number of types of charge that exist, or if there is a different number of types of charge than you found?

Bill and Joe found evidence for two types of charge. They called them “Top” and “Bottom” and made a table to indicate how a Top charge would interact with a Bottom charge, how a Top would interact with another Top charge, and how a Bottom charge would interact with another Bottom charge. They tried to determine experiments that would give evidence of a third type of charge. They tried to think about how a third type of charge would interact with the two types of charge they had found so far.

Make your own table similar to the one described above.

If there were additional types of charge, how would you extend your table? Draw the table with an additional type of charge. Can you determine how an additional charge would interact with each of the charges found so far? Can you definitely fill in all of the spaces in the table for an additional type of charge? Can you fill in possibilities for all the spaces in the table consistent with an additional type of charge? How would an additional type of charge interact with itself?

A4. Summarize your conclusions so far about how many types of charge there are, and the experimental evidence you have to support your claims.

Part B:

B1. If you rub a PVC pipe with a piece of wool, how does the rod interact with the Top and Bottom pieces of tape? How does the wool interact? Rub a glass rod with a piece of silk. How do the glass rod and silk interact with each piece of tape? (You need to rub hard with the silk/glass combination to get a good effect. It works better on clear, dry days)

• This method of charging an object (charging via friction) is called triboelectrification. (The study of friction is called tribology.)

B2. Hang two strips of aluminum foil from a wooden rod using transparent tape so that the pieces of foil are close but not touching. Rub a PVC pipe with wool then touch the pipe to each piece of aluminum foil.

• How do the two pieces of aluminum foil interact with each other? (You may move the pieces of foil by removing them from the wooden rod, touching only the tape NOT the foil.)
• What happens when you bring Top and Bottom pieces of tape close to the pieces of foil? Make sure you try both Top and Bottom pieces of tape with each piece of foil.
• This method of charging an object (touching a charged object to another object) is called charging by conduction.

B3. Consider the following questions. Determine which ones can be definitely answered based on your observations only, and answer them. Determine which questions cannot be answered based on your observations only. Of the questions that cannot be answered, could you answer them by doing further experiments? If so, describe the experiments you could do that might answer the questions.

• Describe the nature of charge.
• Can charge be transferred from one object to another? Explain.
• Is it possible for an object not to have charge? Explain.
• Is it possible for an object to have more than one type of charge? Explain.

B4. How would an object with equal amounts of “Top” charge and “Bottom” charge behave differently from an object with no charge?
• If an object had equal amounts of “Top” and “Bottom” charges, how would it interact with an object with mostly “Top” charges? How would it interact with an object with mostly “Bottom” charges? Explain your reasoning. How would an object with equal amounts of “Top” and “Bottom” charge interact with another object with equal amounts of “Top” and “Bottom” charge?
• If an object had no charge, how would it interact if brought near an object with mostly “Bottom” charges? How would it interact with an object with mostly “Top” charges? How would an object with no charge interact with another object with no charge?

Part C – Conductors and Insulators

C1. Test how the charges move on a PVC pipe using a “Bottom” tape. First rub one end of the pipe. Is the bottom tape attracted or repelled to this end? Now test the other end (that was not rubbed). Is there any charge on this end of the pipe?

C2. Repeat the test of C1, but replace the PVC pipe with an aluminum rod. Hold the rod at one end with your hand, and rub it with wool. Can you detect any charge on the aluminum rod?

C3. Now repeat the test with the aluminum rod, but wrap the end of the rod that you hold with a few layers of the wool cloth so you can avoid touching the rod with your skin. Again rub the rod with wool. Under these circumstances can you detect any charge on the rod?

We call materials like the pipe INSULATORS as they hold excess charges fixed, and materials like copper, aluminum, silver etc (usually metals) conductors as they allow charges to move around. Human beings are also fairly good conductors. Water, especially when there are salts in solution, conducts electricity well. Living cells contain considerable salty water. The earth itself acts like an infinite source of electrons (or sink of electrons).

C4. Explain what happens to the charges in experiment C2 and C3.

Part D - Induction:

D1. Cut 2 pieces of aluminum foil in a rectangular shape 4 cm by 4 cm and hang them side by side, touching each other, as in the picture below, from a wooden rod, using a piece of transparent tape.
D2. Bring a charged PVC pipe near, but not touching, the edge of the piece of aluminum foil. While the pipe is still near the foil, move the pieces of foil apart by touching the tape only. Then remove the pipe.

D3. Use the Top and Bottom tapes to determine whether there is a net charge on each piece of foil.

D4. Repeat steps D1-D3 with two strips of aluminum foil that are initially close but NOT TOUCHING.

D5. What is the difference between the two situations? In step D4, when you remove the charged pipe were the aluminum strips charged?

This method of charging an object (bringing a charged object close to polarize another object) is called **charging by induction**.

D6. Obtain an empty soda can, a PVC pipe, and wool. Lay the can on its side on a table. Rub the pipe with wool and hold the rod near, but not touching the can.

- What happens to the can? Does the soda can contain charge? Does it contain only one type of charge? Does it have more than one type of charge than the other? Could it have equal amounts of “Top” charge and “Bottom” charge? Any other possibilities? Explain.

D7. Based on any of your experiments, do you have evidence for the existence of an object with no charge?

- If so, explain the experiment and your reasoning.
- If not, does this mean that an object with no charge does not exist? Could you do experiments to prove an object with no charge exists? Are there experiments that could be done to prove that an object with no charge does not exist? Explain your reasoning.

**Conclusion:**

1. Please do a write-up for the section of the lab that your TAs specified. You can download an example off the class website.