Objectives

These lab activities will focus on the concepts of charge interaction and charge transfer. You should read all the steps in each part before you start. Work in your assigned groups and maintain a collaborative and communicative team.

For the following activities, you will use several physics simulation programs. Visit https://uglabs.physics.ucr.edu/ for lab downloads and links.

1. Charge with Balloons

1.1: Open the PhET simulation, “Balloons and Static Electricity.” On the bottom left of the simulation, there is an option to show all charges, show no charges, or show charge differences. Click the option for “show no charges.”

1.2: Rub the balloon against the sweater then drag the balloon back to where it started in the middle of the screen. What happens when you let go of the balloon? Explain why you think this is happening. Bring the balloon close to the wall (without touching it) and describe what happens.

- This method of charging an object (charging via friction) is called triboelectrification (the study of friction is called tribology). It works better on clear, dry (low-humidity) days. Why do you think that may be?
1.3: Press the “Reset Balloon” button then click the option for “show all charges.” What happens now when you bring the balloon near the wall (without touching it)? Again, rub the balloon against the sweater, but this time, describe what is happening in terms of positive and negative charges. What happens to the negative charges?

1.4: What is the overall charge on the wall? After rubbing the balloon against the sweater, bring the balloon near the wall and describe what happens.

1.5: Reset the balloons. Click on the “Remove Wall” button then click the button shown to the right to bring a second balloon on-screen. Rub both balloons on the sweater then drag one of them to the right side of the screen. Bring the other balloon near the other balloon (you have to do this quickly before the loose balloon sticks to the sweater). Describe how they react to each other. Why do they behave like this?

1.6: Both the sweater and the balloons start with equal amounts of positive and negative charge. When you charge one of the balloons by rubbing it, is the whole balloon charged or just where the sweater was in contact with the balloon? Since the simulation doesn’t fully encompass the reality of physics, you can’t explore this idea much further -- but can you think of an experiment you could do in real life to test your answer to this question?

1.7: We refer to materials in which charge can freely move around as conductors and materials in which charges remain immobile as insulators. The PhET allowed you to experiment with balloons, a sweater, and a wall. Which of these objects were conductors and which were insulators? What about their behavior allowed you to come to these conclusions?

1.7: Consider the following questions. Determine which ones can be definitely answered based only on your observations from today, and then answer them. Determine which questions cannot be answered based on your observations alone. Of the questions that cannot be answered, could you
answer them by doing further experiments? Describe the experiments you might do to answer the questions.

- We have discovered that charge can be transferred from one object to another by triboelectrification. Are there other mechanisms by which charge can be transferred? Explain.
- Is it possible for an object to not have any charge inside at all? Explain.
- Is it possible for an object to have more than one type of charge (i.e. both positive and negative) at the same time? Explain.

2. Conduction

2.1: The second simulation consists of an aluminum can laying on its side, a glass rod, and a rubber rod. The glass and rubber rods have already been charged for you. Click the “Rubber Rod” button to bring it on-screen. You can click and drag the rod to move it around.

2.2: 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 positive and negative charge? Any other possibilities? Explain.

2.3: If charges are free to move in an object that has equal amounts of positive and negative charge, what will happen when a second object with excess positive or negative charge is brought near? How will charges move within the first object in response to the excess charge? Is a soda can an insulator or a conductor?

2.4: Click on the “Rubber Rod” button again to remove it from the screen then click the “Glass Rod” button to bring it on-screen. Is there any difference in behavior of the can?
Charge

2.5: Click on the “Show Charges” button. Describe how the glass rod’s charges are interacting with the can’s charges. Similarly, bring the rubber rod back on screen and describe how the rubber rod’s charges are interacting with the can’s charges.

2.6: When charges within an object move to separate themselves (i.e. Positive charges predominantly on one side of an object and negative charges on the other), we say that the object has been polarized. Can a conductor be polarized? Can you explain your observations in 1.3 and 1.5 in terms of polarization?

Thought Experiment: Semiconductors can simplistically be thought of as an intermediate state between insulators and conductors. In a semiconductor, charges are normally bound in place (like in an insulator), but when injected with enough energy, the charges can move freely (like in a conductor). Given what we have observed about the behavior of conductors and insulators in this exploration, what would happen if we replaced the glass rod with a semiconductor material? What mechanisms could we employ to inject energy into the bound charges in the semiconductor to force it to act like more of a conductor?

2.7: 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 with the equipment in the lab to prove an object with no charge exists? Can you imagine any experiments that could be done to prove that an object with no charge does not exist? Explain your reasoning.
3. The Van de Graaff Generator

The Van de Graaff generator accumulates charge by the belt rubbing against comb-like metallic needles that are attached to the inside of the dome. You may have seen a Van de Graaff generator in a museum or a physics demonstration in which a person holds their hand against the dome, causing their hair to stand up.

3.1: Open the third simulation and turn on the Van de Graaff generator. Describe what is happening.
Pre-Lab Assignment (1 point)

1. A thin stream of water flows vertically downward. The stream bends toward a positively charged object when it is placed near it. The positively charged object is then removed. What will happen to the same stream of water when a negatively charged object is placed near it? Explain.