On-line activities for electric charge and force labs

Below is the list of experiments (real, video based and data-based) that students can perform as labs when studying electric charge, force and conductors and dielectrics. For each experiment we provide goals, equipment and rubrics for self-assessment. Rubrics can be found at https://sites.google.com/site/scientificabilities/rubrics

1. Observational experiment: how do rubbed objects interact?

Goal: to identify patterns in interactions of rubbed objects
Equipment: Scotch tape
Rubrics for self-assessment Ability to conduct an observational experiment Rubrics B5 and B7.

a. Observe the following experiments and identify patterns. How do rubbed objects interact?
http://islephysics.net/pt3/experiment.php?topicid=10&exptid=164

http://islephysics.net/pt3/experiment.php?topicid=10&exptid=165

http://islephysics.net/pt3/experiment.php?topicid=10&exptid=168

b. Compare the patterns in the experiments above with the patterns in the experiments in the following videos [https://mediaplayer.pearsoncmg.com/assets/_frames.true/secs-experiment-video-29]. Are those patterns consistent with each other?

c. Watch experiments at http://islephysics.net/pt3/experimentindex.php?topicid=10&cycleid=21 How can you explain them? Use your Scotch tape to repeat them. Did the Scotch tape behave the same way as in the videos?

2. Observational experiment: neutral and charged objects interactions

Goal: to identify patterns in interactions of rubbed objects
Equipment: 2 plastic (PVC) tubes or balloons, hanging set-up, rubbing materials (dry paper towel and felt or fleece), Scotch tape, plastic comb, small pieces of paper and small pieces of aluminum foil used in a kitchen.

Rubrics for self-assessment Ability to conduct an observational experiment Rubric B5, B7, and B9.

Design and conduct experiments to examine how neutral (un-rubbed) objects (PVC tubes, balloons), small pieces of paper and small pieces of aluminum foil) interact with rubbed objects such as PVC tubes, balloons, plastic combs, etc.

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a. Record your results for all experiments in words and with a picture. Do your results depend on the type of rubbed object? Do your results depend on whether the neutral object is plastic or metal? Remember to describe what you see in as much detail as possible without fancy words, and without trying to explain anything.

b. What is similar in the behaviors of pieces of paper and pieces of aluminum foil when a charged object approaches them? What is different?

c. What can you say about interactions of charged objects with uncharged objects? (Describe the pattern(s) you noticed.)

d. Devise a mechanistic explanation for how the interaction between the rubbed/charged rod and the un-rubbed rod (plastic or metal) works. Remember, there is *no contact* between the objects. *Hint*: Think about the internal microscopic structure of the rod. Use charge diagrams to illustrate your explanation. Try to come up with at least two competing ideas about the internal structure of materials that could explain why uncharged objects are attracted to charged objects.

e. What are the assumptions that you made in devising your explanation(s)?

3. Testing experiment: do charged objects interact like magnets?

Goal: to choose a productive testing experiment
Equipment: none
Rubrics for self-assessment Ability to design a testing experiment Rubrics C1, C2, and C8.

Your friend Hector says that electric interactions are the same as magnetic interactions because magnets also attract and repel each other. Consequently, he believes that when you rub objects, they become magnetized. What experiment(s) will allow you to test Hector's idea?

a. We decided to test Hector's idea by using a magnet on a pivot with a set of materials that can be charged positively and negatively. Watch the following videos of the experiments that we conducted https://youtu.be/hfXAbx0DKmI and decide which ones can be used to reject Hector's idea and which ones cannot. Explain how you made your decision.

b. Make a judgment about Hector's idea**.**

4. Observational experiment: conducting and dielectric materials

Goal: to identify patterns in interactions conductors and dielectrics with charged objects
Equipment: none

Rubrics for self-assessment Ability to conduct an observational experiment Rubric B5, B7, and B9.

a. Watch the experiments at https://youtu.be/m3WPgv2l93I.

b. Describe your observations for each of the 4 experiments.

c. Think of what model of the internal structure of the conducting and dielectric materials could explain your observations?

d. Watch the experiment at http://islephysics.net/pt3/experiment.php?topicid=10&exptid=190. Do you need to adjust the model that you devised to explain the outcome of this experiment?

5. Application experiment: conducting and dielectric materials

Goal: apply microscopic models of conductors and dielectrics to explain outcomes of 4 experiments.

Watch 4 experiments in the following video https://youtu.be/U4SAcKPKZZI.

a. Sketch the set-up for each experiment and describe the outcome.

b. Can the models of conductors and dielectrics that you devised in Experiment 4 explain the outcomes of the experiments? Justify your answer using charge diagrams.

c. Watch the following video https://youtu.be/6KhjTI9DTUI and answer the following questions: Why do the light metal strips stick out when a charged rod is brought closer without touching? Why do the light metal strips stick out more at the ends of the metal bar than closer to the middle?

6. Observational experiment: electroscope

Goal: To explain experiments involving an electroscope

An electroscope consists of a metal ball attached to a metal rod that passes from the outside through an insulating support into a glass-fronted metal enclosure. A very lightweight metal needle is connected on a pivot on the metal rod (see the photo on the right).

a. Watch the following two experiments https://youtu.be/WQKXrVETwrs and record the outcomes.

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b. Explain the behavior of the electroscope needle (1) when the charged rod touches the electroscope and (2) then when it is brought closer to the charged electroscope without touching.

b. Watch the following experiment https://youtu.be/EY8750PHY-Y and explain the outcome. What can you tell about the electric properties of a human body based on the outcome of the experiment?

c. In the following experiment https://youtu.be/xDznSNxV9eI the experiments that you saw in part **a** are repeated but now the rod that charges the electroscope was rubbed very lightly (it carries a small charge). Describe what you observe and explain the outcome. Why is it different from the outcomes you observed in part **a**?

d. In the following experiment, the experimenter connects a charged electroscope with an uncharged electroscope, the first time with a metal rod and the second time with a plastic rod https://youtu.be/Zqch7ySSufo. Explain the results of the experiments and why the experimenter uses wooden tongs with the inside rubber to pick up the rods connecting the electroscopes.

7. Testing experiment: charging without touching

Goals: 1) to explain how you can an electroscope without touching it with a charged object; 2) test your explanation by predicting the outcomes of the new experiment
Equipment: none
Rubrics for self-assessment: Ability to conduct a testing experiment C1, C4, C5, C7, C8.

a. Watch the following experiment https://youtu.be/wou-B6LVU5M and explain how it is possible to charge the electroscope without touching it with a charged object.

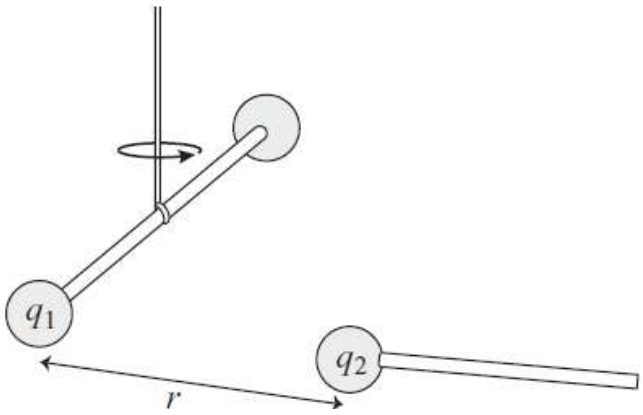
b. What sign of charge is on the electroscope? How do you know? Hint: do not forget that the human body is a conductor.

c. One way to test your hypothesis is to bring the same negatively charged rod to the electroscope and observe the needle. If the charge on the electroscope is the same as the charge on the rod, it will deflect even more. If it is the opposite charge, then the needle will deflect less. Predict what will happen to the deflection of the electroscope needle if it has the charge that you identified in part **b**. After you make your prediction, watch the video at https://youtu.be/HdERlwbvM80. Did the outcome match your prediction? Do you need to revise your answer in part **b**?

8. Observational experiment: What does the force depend on?

Goal: to infer a mathematical relation from data

Equipment: none
Rubrics for self-assessment: Ability to conduct an observational experiment B3, B7 and B8; Ability to analyze data G5



Charles Coulomb used a torsion balance (see the figure at right) to measure the force that one charged ball exerts on another charged ball to find out how the force between two electrically charged objects depends on the magnitudes of the charges and on their separation. Coulomb could not measure the absolute magnitude of the electric charge on the metal balls. However, he could divide charges in half by touching a charged metal ball with an identical uncharged ball.

The table that follows provides data that resemble what Coulomb might have collected. Represent the data graphically. What are the independent variables and what is the dependent variable in Coulomb's experiment? Then analyze the changes in the dependent variable as you change only *one* independent variable at a time. Use this analysis technique (controlling variables) to find patterns in the data and devise a mathematical relationship based on these observations.

Charges (q_1, q_2)	**Distance**	**Force**
1, 1 (unit)	1 (unit)	1 (unit)
1/2, 1	1	1/2
1/4, 1	1	1/4
1, 1/2	1	1/2
1, 1/4	1	1/4
1/2, 1/2	1	1/4
1/4, 1/4	1	1/16
1, 1	2	1/4
1, 1	3	1/9
1, 1	4	1/16

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9. Application experiment: making a photocopier

Equipment: balloon, woolen glove, baking soda

You "write" a letter G with your finger on a rubber balloon using a glove made of wool. Then you bring the balloon close to a plate covered with uncharged baking soda. Some powder grains jump from the plate and stick to the balloon at the places rubbed with wool (see the photo on the right).

a. Explain why the neutral baking soda grains onto the balloon's rubbed part and not onto other parts and why they remain at the locations where the balloon was rubbed?

b. Compare and contrast the outcome of this experiment with how a photocopier works.