Section: Name: BU ID: .

Partner: Name: BU ID: .

Lab 1: Electric charge experiments and Coulomb's Law

Part 1: In this part you will be experimenting with various objects to study electrostatic properties of conductors and dielectrics.

(a) First let us play with a Java simulation (if one browser does not work, try another one).

Follow this link to open a Java simulation (the copy of the link is to be found in file py106weblinks.doc) https://phet.colorado.edu/sims/html/balloons-and-static-electricity/latest/balloons-and-static-electricity_en.html

"Grab" the balloon with the mouse and "rub" it against the coat. What is happening? What particles are moving and what particles stay?

Now move the balloon back and place it between the coat and the wall. Predict, what will happen if you release the balloon? ________________ Now, release the balloon. What is happening?

Now slowly move the balloon toward the wall and observe. What do you think will happen if you let the balloon go when it is very close to the wall? Try it.

Part II

You can close the applet. The following "experiments" should help you to visualize what is happening inside charged objects.

Note: the success in this lab heavily depends on the weather conditions, mostly, on the humidity. All the experiments would be very informative on a dry day. If the humidity today is high, please just apply your best effort.

(b) You have various types of rods available to you, as well as various types of materials with which to rub the rods; you should have an electroscope and a sheet of paper. You should have at least one pair of rods made of the same material (may need to share with another lab station). You can place one rod at a time on a rotating stand. For every experiment, if you observe the clear cause and effect relationship write down your observations and possible explanation for what was happening (otherwise state that the experiment was not informative – like it happens very often in real physics lab).

1. Prepare a couple of small pieces of paper, place them on a table. Take different objects and one by one bring them close to the plate of an electroscope (but do not touch the plate) and then close to the pieces of paper (as close as possible). Do you see anything moving?

2. Select one of the materials (cloths, fabrics), select one of the rods and rub the rod with the material. Bring the rod close to the plate of an electroscope and observe (keep different parts of the rod close to the plate but do not touch the plate) and then close to the pieces of paper (as close as possible) and observe again. Do you see anything moving? Try different combinations of rods and materials (keep track of your combinations and observations). Find a combination of a rod and a material which visibly affects the electroscope (when the rod is close but not touching an electroscope) and describe what does it do to the pieces of paper? If you found a rod-material combination which strongly affect an electroscope, take a piece of aluminum foil and wrap the rod in it and slide the foil off the rod; bring the rod back toward an electroscope and observe.

As the result of your experiments you see that the same rod is actually not “the same”! Sometimes it does not exert any force on other objects, but sometimes it does exert a force.

When an object does not exert a force on other objects we call it neutral.

When an object exerts a force on other objects we say it is charged (it has a charge).

When you change the state of an object from neutral to charged, you charge it.

When you change the state of an object from charged to neutral, you discharge it.

Only that part of the rod which you rub with some material might obtain some charge, while the part you hold in your hand never has a charge! Some rod-material combinations will not result in a strong charge. Some rods will not hold charge for a long time.

3. In the next set of experiments your goal is to observe the situations when two objects attract or repel each other. If you want to use a neutral object use first aluminum foil to discharge it and check with an electroscope that the rod has no charge. If you need to use a charged object first bring it close to an electroscope to see if it actually has a charge.

Take two different rods, one should be neutral and placed on a rotating stand. Another rod should be charged (by rubbing against some material). You should bring the charged rod close to the neutral one and observe. Try all possible rods, including a metal one. Use the table below to keep track of your observations.

Rod 1 (uncharged)	Rod 2 (charged)	Material for charging rod 1	Observation

Did you observe only attraction, only repulsion, or both attraction and repulsion? What is always happening when a charged rod is acting on a neutral object (assuming the charge on the first rod is strong)?

Now, *both* rods should be charged, repeat your experiments (check every time using an electroscope you the roads are actually charged).

Rod 1	Material 1	Rod 2	Material 2	Observation

Did you observe only attraction, only repulsion, or both attraction and repulsion? What does this tell us about electric charge (how many different types of a charge exist)?

4. In this part you will play with an electroscope. Charge a rod (rod 1) and then charge the electroscope by "scratching" its plate with the rod. Then take a neutral rod (rod 2) and bring it close to the plate of the electroscope and observe, then charge the second rod (also rod 2) and repeat an experiment. Try different combinations of rods and materials. Try to explain the behavior of the electroscope when rod 2 is brought close to its plate.

Rod 1	Material 1	Rod 2	Material 2	Observation

Summarize the results of your observations.

In previous experiments you gave an electroscope a net charge by rubbing the electroscope with a charged rod. The electroscope ended up with the same sign charge as the charge on the rod. By following the procedure below, you can give an electroscope a charge of the opposite sign to the charge on the rod. This is trickier, so it involves more steps – the whole procedure is known as *charging by induction*.

This procedure also uses a ground – a ground is essentially a neutral reservoir of charge that is so large that it can donate or accept electrons without becoming particularly positive or negative itself. Houses, for instance, are grounded by being electrically connected to a metal pole that is driven into the Earth – the Earth acts as the ground in that situation.

For the purposes of your experiment, you can act as a ground, because you are considerably larger than the electroscope. Note that the electroscope should start off uncharged. You can ensure this by touching the top of the electroscope with your hand.

Step 1. Select a good rod-material combination which should give a strong charge to the rod (rod 1), and rub the rod with the material to charge the rod. Bring the charged rod close to - but not *touching* it - the electroscope.

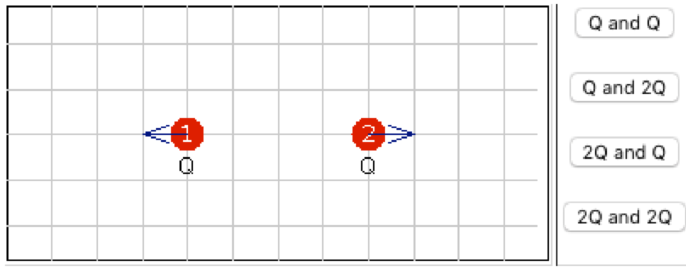
Step 2. Briefly touch the metal part of the electroscope with your finger and then remove your finder away from it – this is what is called grounding the electroscope (use the hand that is not holding the rod, or get your partner to ground it).

Step 3. Take the rod away from the electroscope (note that the rod should never touch the electroscope during this process). The electroscope should register a charge. Now use rod 2 (neutral and then charged) and repeat experiments following the same set of rod and materials as in your table on page 4.

Rod 1	Material 1	Rod 2	Material 2	Observation

If you compare the two tables, do you see any correlation?

Part III:

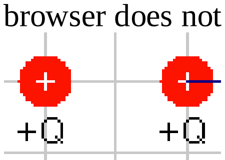


In the picture above you see two identical charges (Q and Q) and a force acting on each charge from another charge. If the magnitude of the force is |*F*|, predict the magnitude of the forces acting between charges when one or both charges are changed.

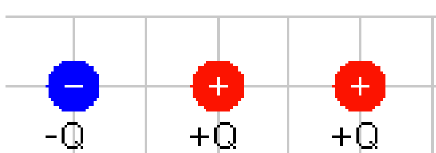
Q	**Q**	**|*F*|**
Q	**2Q**	
2Q	**Q**	
2Q	**2Q**	

Show your work.

Go to the following link http://physics.bu.edu/~duffy/classroom.html, click on Physlets in the Second Semester, and click on "The Magnitude of the Force Between Charges" and check your predictions (if one browser does not work, try another one).



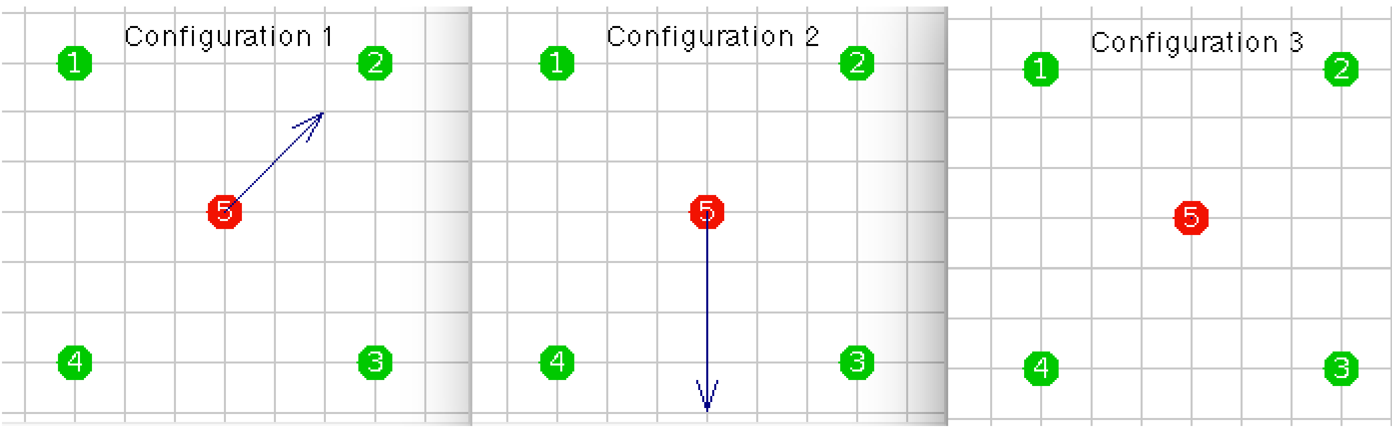
In the picture on the left we see two identical positive charges. The magnitude of the force between the charges is |*F*|.



In the next picture on the left three charges have the same magnitude, but the charge on the left is negative. The two charges on the right are the same as in the previous picture (so we just added one more charge, which is negative). "Calculate" (in terms of |*F*|) the new magnitude of the force acting on the charge on the right.

Go to the following link http://physics.bu.edu/~duffy/classroom.html, click on Physlets in the Second Semester, and click on “Coulomb's Law in 1-D” and check your predictions (first click on “Two positives” and note the force; then click on “All three (with force)” and compare the force with your result).

Below, in each of the three pictures you see five charges with the same magnitude. The charge in the middle (red) is always positive, but other charges (green) have an unknown polarity. In each picture an arrow represents the net force acting on the positive charge in the middle. You goal is to find what polarity the other four charges should have in order to produce the given net force.



Go to the following link http://physics.bu.edu/~duffy/classroom.html, click on Physlets in the Second Semester, and click on “Coulomb's Law in 2-D” and check your predictions (click on “Net + All”).

Equipment

Lab 1
Part I (12 tables): Computers with Java.
Part II (12 tables): various types of plastic rods (at least two of the same material), aluminum rod, various types of cloth, an electroscope, small pieces of paper, a rotating stand, aluminum foil, a soda can, an electrophorus.
Part III (12 tables): Computers with Java.

Unit layout

L1: 150 min

PI: 30 min

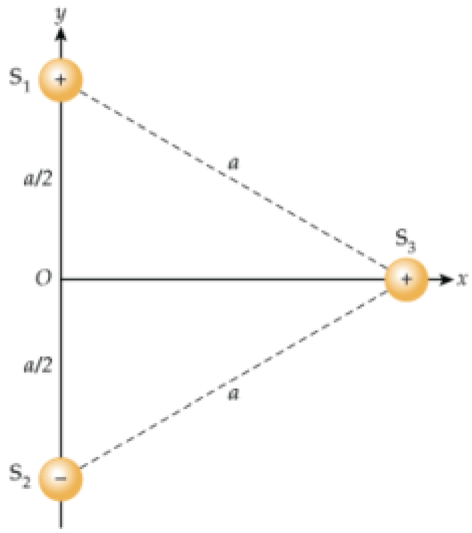
PII: 60 min

PIII: 60 min

PE1: 50 min

Breaks when needed.

Practice Exercise 1:



In the picture on the left three charges have the same magnitude of 10 nC. Distance *a* is 10 cm. Calculate the magnitude of the net force acting on each charge. For each net force calculate the angle between the fore and the positive x direction.