Measuring the Static Charge on Balloons

You should now hopefully have some qualitative sense for how electrostatic repulsion and attraction work. Next, we're going deal with these forces quantitatively, using some fairly simple household materials.

You will need to record all of your information and do all of your calculations in the provided spreadsheet. Also feel free to take a look at the grading key for this spreadsheet. The key will not usually be distributed along with the spreadsheet; this is just to help you get started.

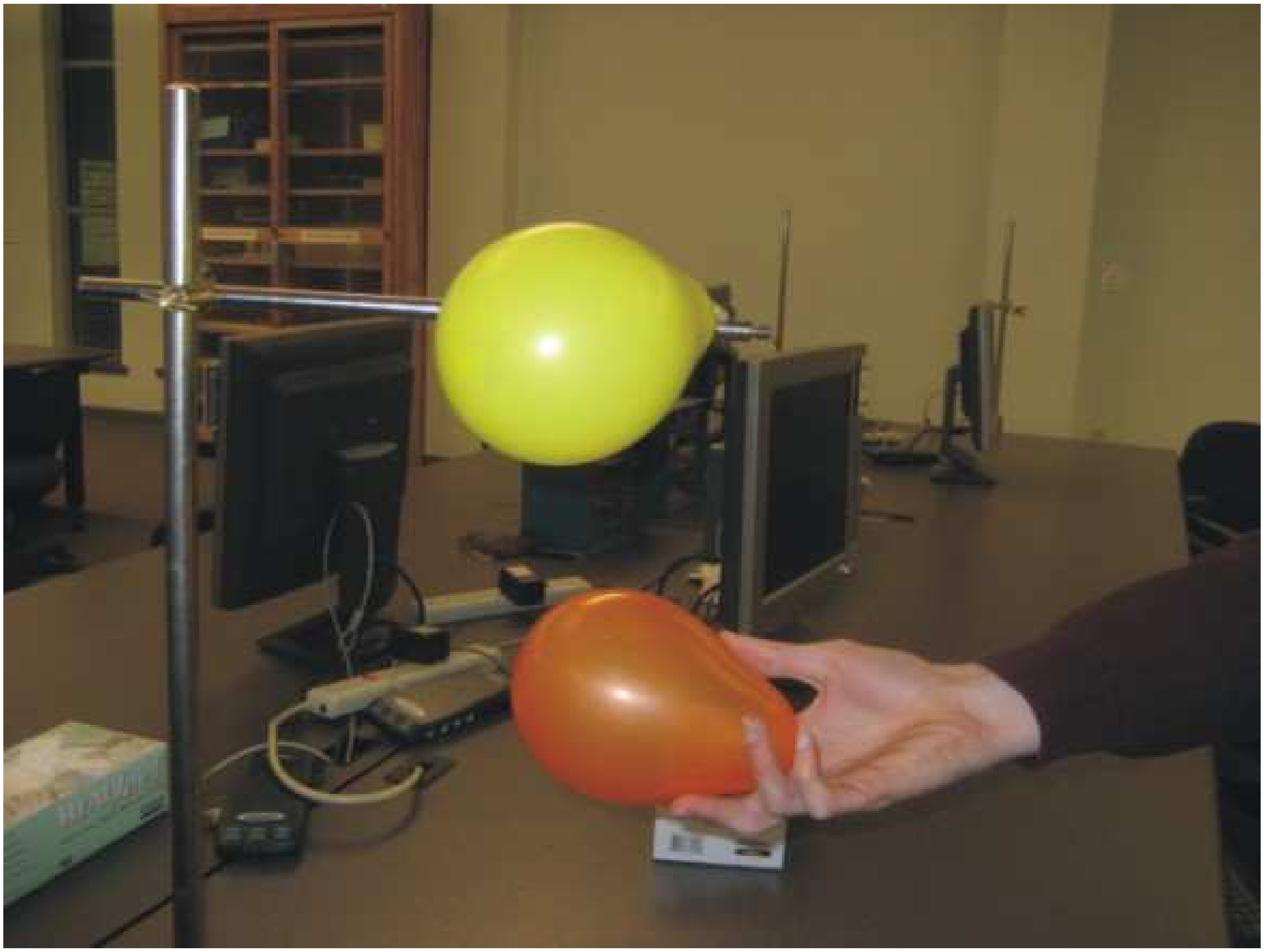
General spreadsheet guidelines:

1. For all entries, make a note of the units your data have. See the example in the spreadsheet for the balloon mass measurements. It is up to you to decide what units to use, just as long as you remember what units you have when it comes time to do calculations.
2. When you have to record the results of a calculation, program the formula into Excel directly. If you don't know how to do this, ask for help. Learning to do calculations in Excel will save you a lot of time in the long run, and also makes it easier for the graders to figure out what you've done.
3. Make sure to put in the CAPA IDs of all your group members, as well as your group's playing card.
4. There are several similar, but not-quite-equal, ways of calculating uncertainties. Please use the approach taught in the prelab. Refer back to this material if you aren't sure what to do.
5. Physical constants like k and g have very little uncertainty associated with them. We will ignore it in this class.

Procedure

1. Measure the mass of each of your balloons using the mass balances located around the room, and record that number in the spreadsheet. Estimate the uncertainty in your mass measurement, and record it. Keep track of which balloon is which.
2. Inflate each balloon to a convenient size.
3. Measure the radius of each inflated balloon (this will be challenging to do accurately). Estimate the uncertainty in these measurements, and record your numbers.
4. Take one of the balloons and rub it thoroughly, all over, with clothing, your hair, or whatever else works. Your goal is to put as much charge on the balloon as possible.
5. Tape the charged balloon to the end of the desk stand as shown below. Consider this to be balloon 1, and the other to be balloon 2.

6. Take balloon 2 and charge it up in the same way as balloon 1.
7. Hold balloon 2 under balloon 1. The balloons should repel each other. Move balloon 2 closer to balloon 1 until balloon 1 is pointing straight out from the end of the rod (see picture).



8. Quickly estimate or measure the distance from the bottom of balloon 1 to the top of balloon 2. Record this measurement D and your estimate of the uncertainty of this measurement in the spreadsheet.

   We now have enough information to calculate how much charge is on each balloon if we make some approximations. First, let's assume that you've managed to get the same amount of charge on each balloon. Second, let's treat each balloon as if it is a point charge, with all the charge concentrated at the center of the balloon. Gauss's Law (which we'll study later) tells us that this is actually a very good approximation.

   When balloon 1 is hanging straight out from the rod, we can be sure that the force of gravity on the balloon is being exactly balanced by the Coulomb force between the two balloons. With that in mind,

9. Calculate the weight of balloon 1.

10. Calculate the distance between the centers of the balloons, R.

11. Use these values together with Coulomb's Law to figure out the charge on either balloon, q.

    Your number should be a tiny fraction of a Coulomb, since a Coulomb is a very large amount of static charge.

12. Your last task is to calculate the uncertainties in your values as indicated on the spreadsheet. Since the uncertainties in your radius and distance measurements will probably be large compared to the uncertainty in your mass balance reading, ignore the mass uncertainties in your calculations.