Electrostatics-1: (~30-40 min)

Objectives:

1) Students will describe the behavior of static electricity as observed in nature and everyday occurrences by:
    1. Listing several occurrences of static electricity that happen in everyday life.
    2. Describing the relationship between static electricity and lightning.
    3. Describing the behavior of objects charged with static electricity in attracting or repelling without touching.
    4. Comparing the amount of static charge produced by rubbing various materials together (e.g., rubbing fur on a glass rod produces a greater charge then rubbing the fur with a metal rod, the static charge produced when a balloon is rubbed on hair is greater than when a plastic bag is rubbed on hair).
    5. Investigating how various materials react differently to statically charged objects.
2) Students will make a connection to Benjamin Franklin and the invention of the Lighting Rod.
3) Students will differentiate between the attraction produced by magnetism and the attraction from electrostatic charge.
4) Students will recognize the connection between magnetism and flowing charges.

Materials Needed:

1) Van de Graaff Generator
2) Long pointy metal rod
3) Silk, and Fur
4) Glass, Vinyl, and Aluminum Rods
5) Balloon
6) Rod Magnet
7) Wire winding with a light bulb attached.
8) Puffed rice
9) Isolating Stand for student
10) Isolating Stand for Rods.
11) Disposable Aluminum plates.
12) Cotton.

Strategy:

Note: This may be given as a fast-paced series of demonstrations, or a few may be selected to slow down the pace.

Initial Setup:

Initially set up the Generator, and display the equipment to be used. Ask the students to guess what the topic of the lesson is (a few will infer it is about static electricity), validate their responses, and correct them by saying the lesson will be about Benjamin Franklin. (For some background visit: http://www.ideafinder.com/history/inventors/franklin.htm) Benjamin Franklin invented the lightning

rod, and we will go through a few of the observations he made that led him to that invention.

Ask the students to raise their hand, when they have experienced the following:

1) Walking around and then getting shocked when touching a metal object.
2) Walking around and seeing their hair stand up and get staticky
3) Played with a balloon and make it stick to the wall after rubbing it on their heads
4) Seen a lighting bolt
5) Making a candy wrapper jump into their hands... (others)

WHY do these thing happen?

Benjamin Franklin had experiences similar to these and also wondered how these things came to pass and WANTED to find an answer. (Needless to say, he did not have GOOGLE)

(As the lesson goes on, make references on how Benjamin Franklin used the scientific method to answer this question)

Rods Demos:

Some simple observations he made were done by rubbing two materials together.

- Rub the rods with different clothes
- Use the Isolating stand to place one of the rods so that it is free to rotate.
- With a similar rod, charge it up and push without touching the hanging rod.
- Do bring to their attention that you're not touching the rods, and do use the charged rod to change the direction of rotation.

ask: WHY does this happen?

Explain:
Benjamin Franklin concluded that when the objects were rubbed together, one of them must put or take away something from the other.... something so small he could not see what it was.

- When two materials are rubbed together, one of them may rip electrons out of the other.
- Everything has both positive and negative charges. (even the students!!!) The difference between them and a charged object is that they have the same number of positive and negative charges therefore the net charge for most things equals zero.
- (reiterate) When two materials are rubbed together, one of them may rip electrons out of the other, so there is now the number of positive and negative charges is not the same, so there is now a net charge (optional, make connection with math and the use of positive and negative numbers; and work out a few scenarios where the result is either a positive net charge or a negative net charge)

You may repeat, while asking if they have seen similar behavior with other kinds of rods. (Someone may volunteer magnets, if not, coax them into answering that...)

- Use the hung charged rod, and bring in the bar magnet... Show the students that the behavior does not take place because of magnetism....
- Mention that there is a relationship between electricity and magnetism, but this behavior does not take place because of magnetism.
- Rub other materials and experiment with the charges. Students may come up and play with some of the rods.

- Bring their attention that some rods repel the hanging rod and some will attract the hanging rod.
- Use similar rods and show that when the rods are the same, (i.e. same rod, same rubbing, same charge) they repel, but make sure the students come out with the observation.

Explain:
Benjamin Franklin made similar observations that the students are now making!

- He stated that objects with the same charge will repel each other, and objects with opposite charges will attract each other.
- Thus... Opposites Attract
- ALSO, (reiterating the points made earlier) when charges are taken from one object to another, it only the electrons that move. (you don't move the protons around)
- (If inclined, you may say that Franklin did not know that and got it backwards....)

Now, hang a rod with a known charge, and charge a different rod (i.e. unknown charge) ask the students how can you possibly know what type of charge the unknown rod has?

** Checkpoint: By this time make sure the students understand: 1) equal charges repel, opposites attract. 2) electrons can be easily moved from one object to another.

Van de Graaff Generator Demos:

Time: (~5 min)
We have just played with rods and seen that we can use cloth to take away or put electrons onto a rod.

- Turn on Generator

This device (the generator) works very much the same way. There is a belt that takes a way electrons from the bottom, and puts them on the top where there is a big metal ball. Now, we've said that the electrons don't want to be near each other because they have the same charge, so they try to get away. from the big metal ball. But... Where do they go?
Well, they stay there until there are too many, and they find somewhere they can jump to.

- Place the discharge rod near the sphere but do not touch it. Watch their reaction. :-)
  (For the brave soul... use your hand instead of the rod, it is not that bad)

You may use the following demos to cement the concepts seen with the rods: (NOTE: practice before hand, some of them need to have the generator off before so that they can be properly set up)

- Use a rubber ring on top of the charged sphere so that you can put puffed rice in it. The rice will charge up and repel the sphere and other rice grains.
- Ask a student to stand on the isolating platform and their body (and hair) will charge up making the hair stand. (You may ask the student to remain isolated and discharge through you by using their finger to shock you)
- Place a few aluminum plates on top of the charged sphere; again they will charge up and float away.

This has been fun, but going back to Benjamin Franklin, he noticed that you can put more and more charges, and he wondered whether or not he could charge the tip of a Bayonet (a knife in front of a rifle) to shock the enemies...

- Show again how the generator discharges using the discharge rod (or your hand)
- Bring in closely the sharp metal rod (you can bring it closer, and closer, but don't touch...)
- You can bring in the discharge rod (or your hand) close to the charged sphere but behind the sharp rod, and nothing.... (but as soon as it gets between the sharp rod and the charged sphere it

will discharge.)

What happened?
So Benjamin Franklin observed the effects of static electricity on a sharp point, and thanks to that observation, he invented the lightning rod. That invention is widely used. Did you know that airplanes have several lightning rods on their wings... (Explain that the planes rub the atmosphere, get charged and use the sharp lightning rods to get rid of that charge, and make connections to the observations the students have made with the charged rods, and the lightning rod demos.)

Cotton Demo:

Time About 1 min.

- Take the PVC pipe, and charge it up by rubbing it. Ask the students if they know what will happen to the pipe... (It'll get charged)
- Take a fluffed-up piece of cotton (a very small piece, so that it is light, and fluffed up so that the students can see it) and hold it near the PVC pipe (but don't touch).
- Is the cotton charged?

Explain that even though the cotton is not charged, the charges in the pipe are still affecting the charges in the cotton. repelling a few, and attracting the others.

- Release the cotton, should get stuck to the pipe. Ask the students what charge should the cotton be now that it touched the pipe. (should be the same charge now....)
- Swish and Flick the pipe to release the cotton (don't touch the cotton to release it) you may need a few times to get it to release... (may reference Harry Potter, and no, you're not a witch...)
- Since the pipe and the cotton have the same charge, they will repel each other, and you may levitate the cotton and guide it with the PVC pipe. Ask the students to explain what is taking place.

Winding Coil Demo (optional):

Time About 2 min. Earlier a mention was made about magnets, and that static electricity was not magnetism, but there is a connection between electricity and magnetism.

- Use the bar magnet and the winding coil.
- Move the magnet back and forth through the winding coil.
- Ask the students to observe the light bulb, and notice how magnets were able to affect the electricity in the coil. (Use this as a hook for the next lesson on Magnetism and Electricity)

Closing:

At the beginning of the class we mentioned that the lesson was about Benjamin Franklin. What are some of the things we learned from his life? Reiterate that he was a scientist and found ways to answer the questions he had. He invented the lightning rod.

Also thanks to Benjamin Franklin we now know quite a few things about Static Electricity.

Performance Assessment:

1. As the demonstrations takes place, as the students to verbally communicate their observations using the following checkpoints.
    1. Charges that are the same will.... (expect repel) and opposite charges will... (expect atract)
    2. During the demo with the rods, place a rod with a known charge suspended in the stand, and ask the students to predict what will happen if a similar rod (i.e. with the same charge) gets closer to it.
    3. Also, with a suspended rod.
2.