Physics 305 Lab E01 name _____

Basic electrostatics exploration activities partner _____block _____

1/17/03

Guide for Lab Assistants

materials list/ set-up per station

2 styrofoam cups suspended by thread

1 large piece of rabbit fur

1 balloon

metal rod or pan

2 suspended small aluminum foil balls

small paper bits

thin stream of water

tape

thread

plastic wrap

plexiglass

plastic collar strips

styrofoam bars or other large pieces

Your goal in the following investigations is to draw some basic conclusions about electric charging and electric forces. Do not write any complicated equations which you may know from past experience. All conclusions must be drawn from observations in these activities.

In these investigations you must handle the materials carefully or they will fool you and lead you to incorrect conclusions! All observations must be easily reproducible.

Between steps, be sure to neutralize the objects by touching them all over with your hands (your body acts as sort of a charge reservoir and takes up or gives away electrons to the objects as needed--neat!)

All explorations should be accompanied by pictures and word explanations. Some parts of the lab direct you to use certain materials, other parts leave you to be creative and try various materials--be sure to keep an accurate record of what you did and what you observed. Be prepared to demonstrate and explain any part of this lab for a grade.

Focus I Charging by Rubbing/Friction

A. *Can an object become charged due to friction from another object?* Equally rub both of the suspended Styrofoam cups with the fur. How do the two equally rubbed cups react to one another when they are brought near one another?

   Make sure students have rubbed both styro cups on all sides before they bring them near each other

   Their "picture" here – and in every part of the lab – should be accompanied by a force diagram showing the electric force on each object. The force vectors for both objects should have the same length, since the forces are equal in magnitude (they might not observe this, but they should expect it based on Newton's third law)

B. *Does more rubbing yield more charge?* Explore the interaction of the two cups when they are rubbed a little or a lot. Summarize your findings.

Make sure they have touched both cups on all sides with their hands (to neutralize the cups) before starting each trial in this part

Questions for lab assistant to ask students:

What happens if you increase the charge on just one of the cups ? How does this compare to what happens if you increase the charges on both cups ? They should observe (and tell you) that the electric force increases in proportion to the charges of both objects

C. *If one object becomes charged due to friction with a second object, does the second object also become charged?* How can you tell? Explore the interaction of the balloon and the fur after rubbing the balloon with the fur. Summarize your investigation and findings.

Again make sure that they have rubbed all sides of the balloon (not just one part of it)

This is the first force diagram where they should show attraction of the two objects

Ask them to explain why they think the two objects got the charges they got. They need to realize that electrons are being transferred from one object to the other.

Ask them this, too: assuming that both objects started out neutral, compare the magnitudes and signs of the charges after they have been charged. They need to realize that the two objects will have opposite charges, because one has gained electrons (so has an excess of electrons) and one has

lost electrons (so it has a deficit of them). They also need to realize that the magnitude of positive charge on one object will equal the magnitude of negative charge on the other object, since no charge has been lost or gained overall (conservation of charge)

D. *When an object (insulator) is charged by friction does only the small "rubbed" part gain and hold charge, or is the entire object charged?* Explore this with a balloon rubbed with fur on only one part, a neutral cup, and a cup rubbed all over with fur. Summarize your findings.

Have them call you over when they start this one (before they actually do anything).

They need to do a good job of neutralizing the balloon and cup before trying this.

First, they should bring the balloon near the neutral cup. They should notice that the neutral cup is attracted to the charged part of the balloon but not affected by the neutral part of the balloon. Ask them what they can conclude about the charged of the balloon and the cup from those observations – they should tell you that: 1) the cup is neutral, since it was not attracted to the neutral part of the balloon; 2) the charge on the balloon stayed on only one part of the

balloon; 3) the neutral cup was attracted to the charged balloon.

Next, they should bring the balloon near the charged cup. They should notice that the cup is repelled by the charged part of the balloon, but attracted by the neutral part of the balloon. Have them explain this. 1) the cup and charged balloon must have the same charge, since they repelled each other. 2) the cup was attracted to the neutral part of the balloon.

They need good diagrams and written records for all these observations.

E. *Are there some objects (metal--conductors) which do not become charged by friction with other objects?* Try rubbing the metal rod with the fur and then see if the rubbed rod interacts with the hairs on your arm. Summarize.

They will need to use the aluminum foil or pie plate here. They should see no effect.

<u>Focus II Electrostatic Force Characteristics</u>

A. *Do two charged objects have to be touching to exert a force on one another?* Describe your experimental observations which lead to your conclusion.

B. *How does the interaction between two charged objects change as the distance between them is increased? or decreased?* Describe your experimental findings which lead to your conclusion.

Electric force increases as distance between two objects decreases, and vice-versa.

C. *Are electrical forces only attractive? only repulsive?* Describe your experimental findings which lead to your conclusion.

Electric forces can be either attractive or repulsive. The electric force of one object on another is attractive if the two objects have opposite charges (examples: fur and balloon; fur and Styrofoam cup). The force is repulsive if the two objects have like charges (example: styro cup and styro cup). Also, a neutral object is electrically attracted to any charged object (several possible examples here).

D. *How does the interaction between two charged objects change as the charge on one or both of them is increased?* Describe your experimental findings which lead to your conclusion.

The electric interaction between two charged objects increases whenever the charge of either of the two objects is increased.

E. *Is electrical force greater than gravitational force?* Describe your experimental findings which lead to your conclusion.

The answer depends on the charges and masses of the objects involved. They should recognize that it is possible for objects with relatively little charge (i.e. balloons rubbed with fur) to exert electrical forces on other objects that are greater than Earth's gravitational force on those other objects, i.e. to accelerate those other objects upwards. Examples they could give include raising a person's hair with a rubbed balloon, having a balloon stick to rabbit fur or to a person's shirt, etc. Whatever example they give, they must show a force diagram for the object that is experiencing the electric force greater than the gravity force.

Focus III Charging by Contact

A. *Can a neutral object become charged by simply touching a charged object?* Rub the balloon with the fur. Touch the charged balloon to a suspended aluminum ball. Observe the interaction of the ball and the balloon after they have touched. You should get an obvious and strong behavior. From your observation, what do you know about the charge of the aluminum at this point?

The balloon should repel the ball – they have the same charge. The balloon gave charge to the ball.

B. Touch the charged aluminum ball to the other (neutral) aluminum ball. How do the two balls interact after briefly touching? From your observation, what do you know about the charge of the two aluminum balls at this point?

They must be careful not to touch the aluminum balls with their hands; touching the charged ball will neutralize it.

Focus IV Interaction of Charged and Neutral Objects

A. *Do two neutral objects exert an electrical force on one another?* Neutralize both of the suspended aluminum balls. Bring them near to one another and observe their behavior. Describe what you see and draw a conclusion.

B. *Is there an electrical interaction between a neutral object and a charged object ? If so, is the force attractive or repulsive?* Charge a balloon by rubbing with the fur. Hold the balloon near some small paper bits on the tabletop. Describe the behavior the paper bits as the balloon is moved closer and closer.

A diagram showing separation of charge (polarization) of the paper bits is required here. The side of the paper near the balloon will have an excess of charge opposite in sign to the balloon. The side of the paper opposite the balloon will have an excess of charge the same sign as the balloon.

Ask them to compare the magnitudes of the surface charges of the paper – they are equal, since the total charge of the paper must still be zero – there was no transfer of charge to the paper, since nothing touched the paper.

Along with the diagram must be a force diagram showing the forces on different parts of the paper. The force on the far side of the paper is less than the force on the near side of the paper, since electrical forces decrease in strength with distance, and since the amount of charge on both sides of the paper is equal.

If they can not come up with the above explanation on their own, refer them to the book discussion of separation of charge in neutral objects on pp. 469-470 (don't just tell them the answers).

If they can explain all the above things to you, next ask them how they think the paper could have become polarized. If they say that charges inside the paper moved away from the charged balloon, remind them that paper is an electrical insulator, so charges are not free to move around inside it. Don't tell them the correct answer, just get them to think about it. Tell them that the last lab exercise will give them a hint about what actually happens inside the paper to separate the charge.

C. Bring the charged balloon near to (but not into!) a thin stream of water. Describe what you see. Explain why you see what you see. Hint: is there something special about water?

They need a diagram similar to the one in the previous part, but here they need to explain that water is a polar molecule, so that individual water molecules will rotate to create opposite surface charges on the water.