

While walking through your town's commercial district one Saturday, you notice a large poster in a hobby shop window:

WANTED: A simple method for measuring electric charge using only these materials: rubber balloons, string, and fur cloth. Mass and distance measuring devices are allowed.

PRIZE: \$500 for the first successful method submitted.

Materials:

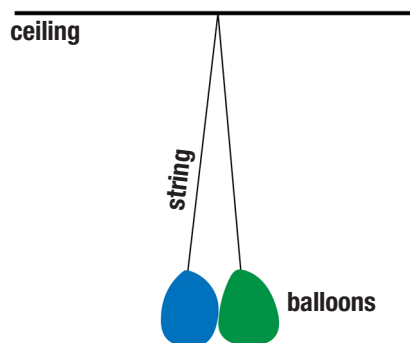
- rubber balloons (2)
- string
- cloth fur
- ruler with millimeter markings
- scale

Procedure:

- a. Inflate both balloons to roughly three-quarters capacity.
- b. Cut two pieces of string, each a few meters long.
- c. Pair each string with one of the balloons and weigh them, balloon and string together, on the scale.

	Balloon/String Pair One	Balloon/String Pair Two
Mass (g):		

- d. Fasten one end of each string to the ceiling and the other end to a balloon so that the balloons hang at about shoulder height, touching each other (see diagram below).



- e. Using the fur cloth, rub each balloon 10 times.

1. How will the balloons react to each other after being rubbed by the fur? Why?

Name:

Date:

- f. Using the ruler, measure the distance from the center of one balloon to the center of the other. Next, measure the vertical distance from the ceiling to the center of either balloon (they should be at the same height). Record both measured distances below:

	Center to Balloon Center	Ceiling to Balloon Center
Distance (m):		

- g. In the space below, draw a free-body diagram of one of the balloons after it has been rubbed by the fur cloth, including all the forces acting on it:

2. What is the gravitational force acting on the balloon? Give your answer in newtons.

- h. Draw a diagram of the two balloons that includes the angle formed by the two strings hanging from the ceiling. Give the angle a name, such as theta (θ), and label it in the diagram:

Name:

Date:

- i. Considering this diagram and the free-body diagram, write an equation for the vertical forces acting on the balloon:
- j. Use the two measured distances to write out the length of each leg of the right triangle whose hypotenuse is the string. What is the angle formed at the top corner of the triangle? Give your answer in degrees.
- k. Using the value of the angle determined in the previous question, write an equation for the horizontal forces acting on each balloon. Assuming the charge on each balloon is the same, what is the magnitude of that charge?

Name:

Date:

- I. Rub each of the balloons 10 more times with the fur cloth.
- m. Measure the new distances from the center of one balloon to the center of the other, and from the ceiling to the center of one balloon, recording the values in the table below:

	Center to Balloon Center	Ceiling to Balloon Center
Distance (m):		

- n. Solve for Q, the charge on each of the balloons, using these new measurements.

3. Was the new value of Q twice the old value? Why or why not?

4. Confident about your chances of winning the \$500 prize, you must now write up your proposed method and findings. Assuming the reader has no background in physics, explain your method and how you were able to solve for the charge on each balloon using only the permitted materials.
