Name KEY Date_____ Partner(s)_____

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Physics Laboratory
Electric Charge

In this laboratory exercise we will examine the interaction between charged objects in order to develop a model for electric charge.

Materials:
- magic tape
- aluminum coated pith ball
- wooden dowel with string attached
- acrylic rod
- piece of wool cloth

I. Electrical Interactions

A. Press a piece of tape, about 10-15 cm in length, onto the surface of your table. (For ease in handling, make "handles" by folding each end of tape to form portions that are not sticky.) Then peel the tape off the table and hang it from the edge of the table.

Describe the behavior of the tape as you bring objects toward it. (e.g., a hand, a pen, etc.)

The tape should move toward any object brought close to it.

B. Make another piece of tape as described above. Bring the second tape toward the first. Describe your observations.

The tapes should repel each other.

How does the *distance* between the tapes affect the interaction (force) between them?

The greater the distance, the less the force.

C. Two members of your group should press a tape onto the table and write "B" (for bottom) on it. Then press another tape on top of each B tape and label it "T" (for top).

Pull each pair of tapes off the table as a unit. After they are off the table, separate the T and B tapes.

Describe the interaction between the following pairs of tape when they are brought near one another.

two T tapes	two B tapes	one T and one B tape
repel	repel	attract.

We say that the tapes are ***electrically charged*** when they interact as you have observed.

The two T tapes must have the same kind of charge because they were charged in the same way, and likewise the two B tapes must have the same kind of charge. But the T and B tapes must have different kinds of charge since the T-B interaction is different from the T-T and B-B interaction. How many different kinds of charge do there appear to be? They are referred to as "positive charge" and "negative charge."

D. Obtain an acrylic rod and a piece of wool. Rub the rod with the wool, and then hold the rod near newly made T and B tapes.

1. Compare the interactions of the rod with the tapes.

rod and the T tape	rod and the B tape
should repel	should attract.

We say that the rod is also ***electrically charged*** because the rod interacts with the tapes in the same way the tapes interacted with each other.

2. By convention, the acrylic rod is said to be positively charged when rubbed with wool. We know that two T tapes repel, two B tapes repel, but a T tape and B tape attract. The acrylic rod repels the

__T__ tape and attracts the __B__ tape. Which tape, T or B, is positively charged? __T__

3. Summarize your observations in terms of "like charges" and "unlike charges."

Like charges repel. Unlike charges attract.

4. How does the strength of the force vary with the proximity of the charges to each other?

Force decrease with increasing distance, and vice versa.

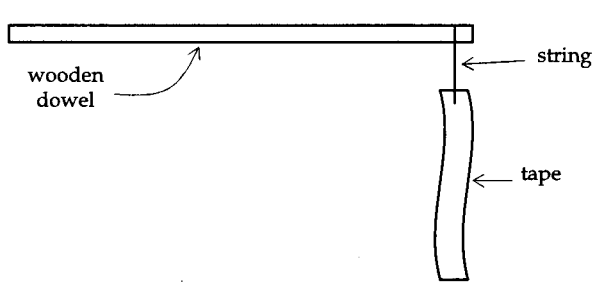
Are your observations consistent with Coulomb's law? Explain.

Yes. Coulomb's law says the force varies inversely with the distance.

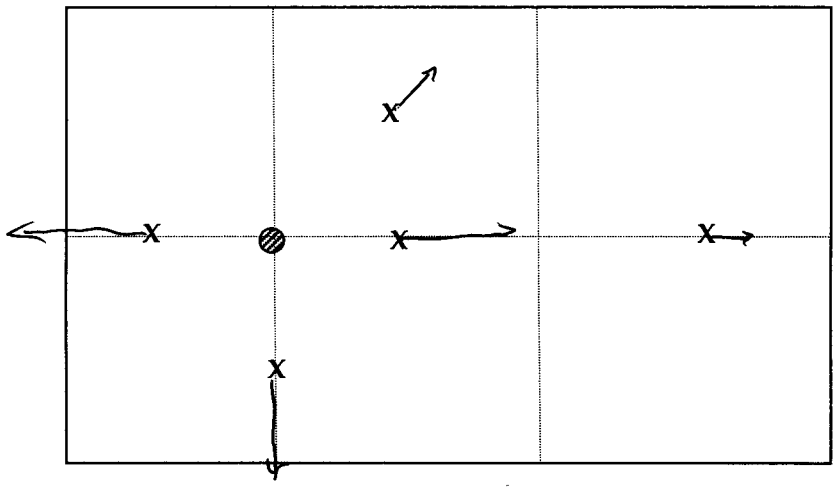
Please remove all tape from the tabletop before continuing.

II. Superposition

A. Rub the acrylic rod with the wool in order to charge it. Attach a piece of positively charged tape to the string suspended from the wooden dowel

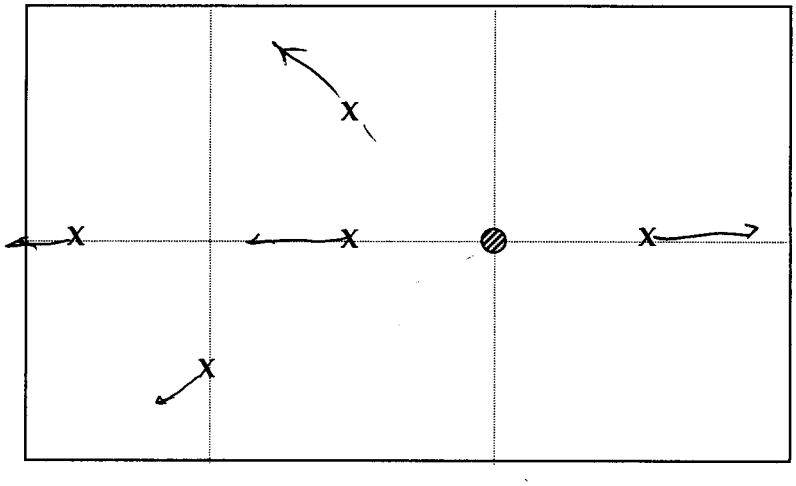


B. Hold the charged acrylic rod vertically upward. Take the charged tape (hold the wooden dowel) and move it to various positions around the rod. The picture below shows a *top* view of the rod and the **X**'s represent the various positions to hold the tape.

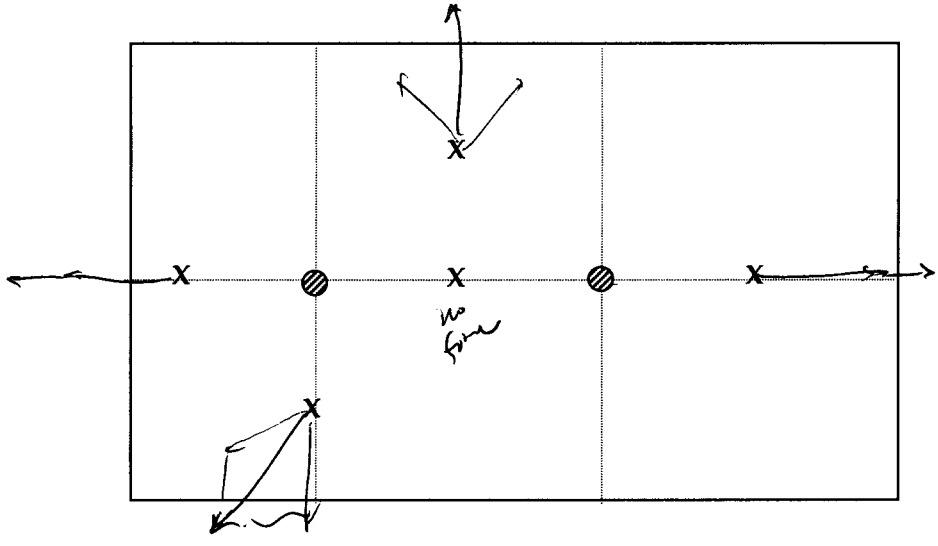


Based on your observations, draw vectors to represent the electric force on the tape at each of the points marked by an "**X**." Remember that the length of the vector should be drawn proportional to the strength of the force.

C. *Suppose* the first acrylic rod is removed and a second identically charged acrylic rod is placed to the right of the first rod, as shown in the picture below. Draw vectors to represent the electric force exerted on the tape at the positions marked by **X**'s. Use the same vector length proportionality you used in part B to represent the strength electric force in this case.

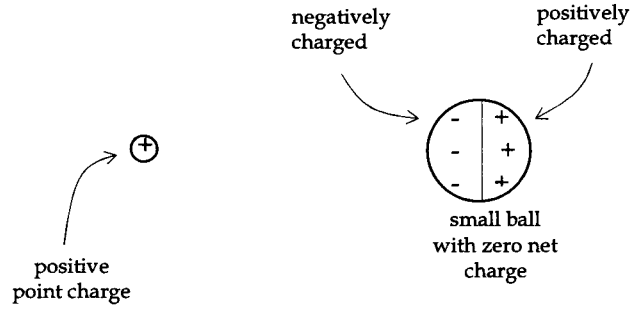


D. When both rods are present, each exerts its own force and the *net* electric force at each point in space is the vector sum of the two. Draw vectors to represent the *net* electric force exerted on the tape at the positions marked by **X**'s. Refer to your diagrams in parts B and C.



III. A model for electric charge

A. A small ball with zero net charge (electrically neutral) is positively charged on one side and negatively charged on the other side. The ball is placed near a positive point charge, as shown.



Would the ball be attracted toward, repelled from, or unaffected by the positive point charge? Explain.

Attracted. The negative charge on the small ball is closer to the positive point charge.

Is your answer consistent with Coulomb's law? Explain.

Yes, smaller distance, the larger the force.

B. Hang an *uncharged* metal-coated pith ball from an insulating string attached to the wooden dowel. Then charge a piece of tape as in part A of Section I and bring the tape toward the ball.

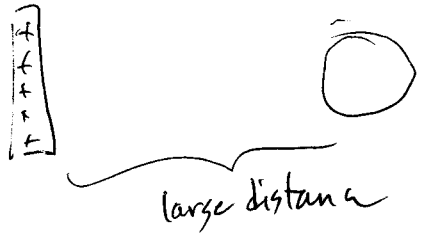
Describe what you observe.

pith ball should be attracted to the tape.

Through careful observations of physical phenomena, scientists develop models, or mental pictures, to account for observations. These scientific models can also be used to predict physical behavior. From observations of electrical phenomena we can develop a model for electric charge.

C. Use your model for electric charge to account for the electrical attraction between the charged tape and an uncharged metal ball. As part of your answer, draw a sketch of the charge distribution on the tape and ball both before and after they are brought near one another.

before



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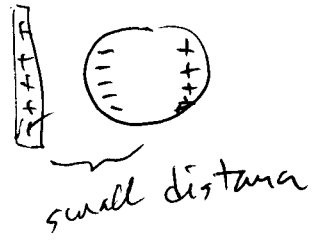


D. Two students discuss what would happen if, instead of being uncharged, the metal-coated pith ball in part B had a *small* net charge. (Assume the ball and the tape are both positively charged.)

Student 1: *"Since the ball is a conductor, the excess charge will be evenly distributed on the surface. Since the ball and tape are positively charged, they will repel."*

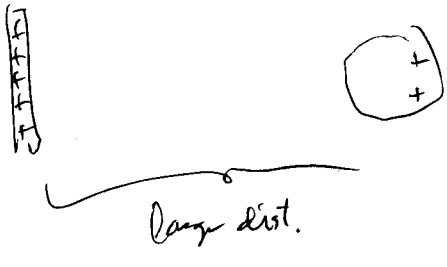
Student 2: *"The tape will repel the positive charge on the ball and attract the negative charge on the ball. If the excess positive charge is not too much they may still attract each other."*

Student 1: *"That can't be true. If the ball has a net positive charge then there is no negative charge on the ball."*

Do you agree with either student? Explain your reasoning.

Agree with student 2: Even with the ball being positively charged, by bringing the tape (positive) close to the ball there will be negative charges on the ball that move closer to the tape. The smaller distance can result in a greater force of attraction then the repulsion of the positive charges on the ball from the tape.

before



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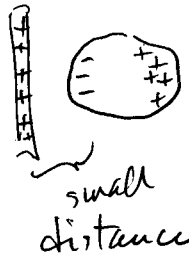
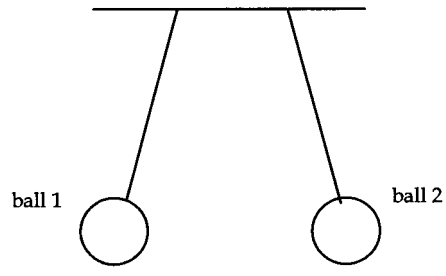
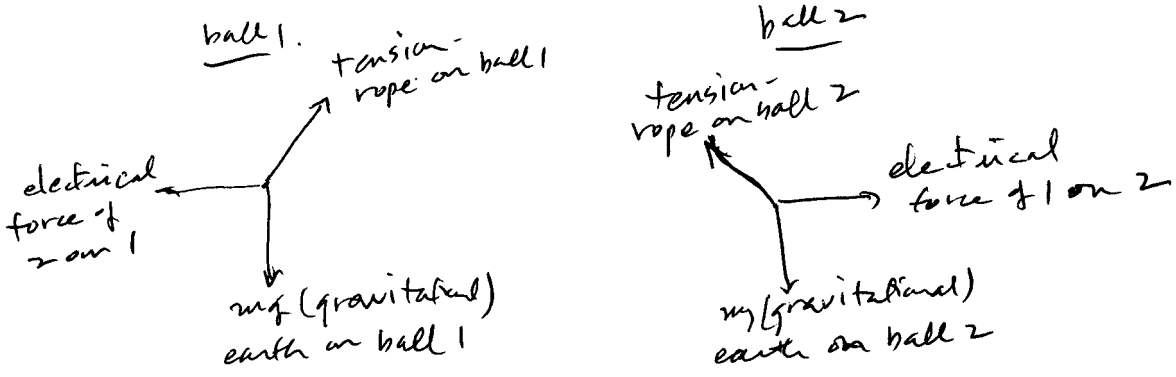


E. Two identical *metal* balls are suspended from the ceiling by insulating strings. Initially, the balls have the same positive net charge.



1. Draw a free-body diagram for *each* ball. Label each force to indicate

- the type of force (gravitational, normal, etc.)
- the object exerting the force
- the object on which the force is exerted
- whether the force is a contact or noncontact force

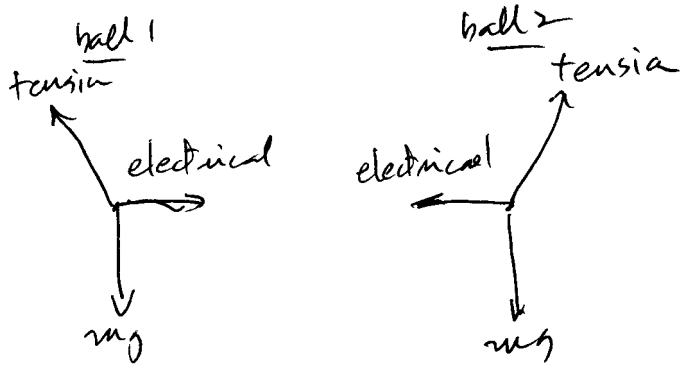


2. In your diagrams, identify the forces that are the action-reaction pairs. (Remember Newton's Third Law.)

Only the electrical forces: 2 on 1 and 1 on 2

3. Suppose that the charge on ball 2 is decreased so that it is less than that on ball 1. How do the free body diagrams for the balls in this case compare to the free body diagrams that you drew in part 1? .

Still the same, except that the strings will be more vertical because the electrical force decreased.

4. Suppose that the net charge on ball 2 is reduced to zero. How do the free body diagrams for this case compare to the diagrams you drew in parts 1 and 3 above? .

the electrical forces become attractive and the tension changes direction