Bell Ringer: Effects of Distance and Charge on Electric Force – ID: 13709

Based on an activity by Charles W. Eaker

Time required
15 minutes

Topic: Electricity and Magnetism

- *Use Coulomb's law to solve problems of force between electric charges.*
- *Solve problems involving point charges and force using vector addition.*
- *Solve problems for the strength and direction of an electric field.*

Activity Overview

In this activity, students explore the relationship between force, charge, and distance for two charged particles, i.e., Coulomb's law. Students observe how force changes with distance by moving a charged particle. By fitting the data collected for force vs. distance to a power regression equation, students determine that electrical force is inversely proportional to distance squared. After determining the dependence of electrical force on charge, the students are able to write the Coulomb's law equation.

Materials

To complete this activity, each student will require the following:

- *TI-Nspire™ technology*
- *pen or pencil*
- *blank sheet of paper*

TI-Nspire Applications

Graphs & Geometry, Notes

Teacher Preparation

Before carrying out this activity, review the units of force and electrical charge. You may also want to review the representation of forces with vectors.

- *The screenshots on pages 2–4 demonstrate expected student results. Refer to the screenshots on pages 5 and 6 for a preview of the student TI-Nspire document (.tns file).*
- ***To download the student .tns file and solution .tns file, go to education.ti.com/exchange and enter "13709" in the search box.***
- *This activity is related to activity 9747: Coulomb's Law. If you wish, you may extend this bell-ringer activity with the longer activity. You can download the files for activity 9747 at education.ti.com/exchange.*

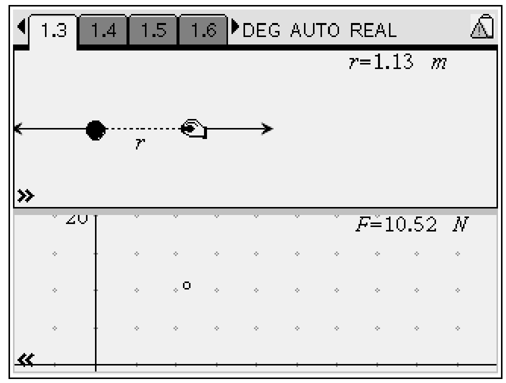
Classroom Management

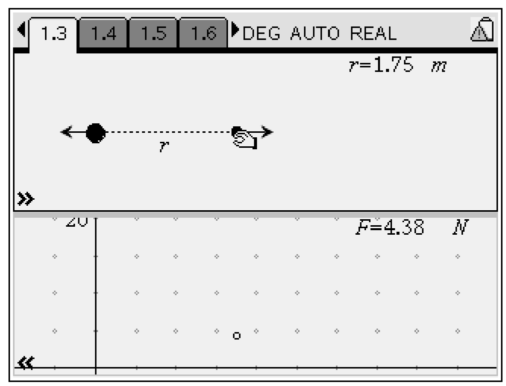
- *This activity is designed to be* ***teacher-led*** *with students following along on their handhelds. You may use the following pages to present the material to the class and encourage discussion. Note that the majority of the ideas and concepts are presented only in* ***this*** *document, so you should make sure to cover all the material necessary for students to comprehend the concepts.*
- *Students may answer the questions posed in the .tns file using the Notes application or on blank paper.*
- *In some cases, these instructions are specific to those students using TI-Nspire handheld devices, but the activity can easily be done using TI-Nspire computer software.*

The following questions will guide student exploration in this activity:

- How is electrical force related to the distance between charged particles?
- How is electrical force related to the magnitudes of the charges of separated particles?

In the first part of the activity, students vary the separation of two charged particles. They observe the change in electrical force with varying separation. With a manual data capture of force and distance data, a graph of force vs. distance, and a power regression, students determine the mathematical relationship between force and distance. In the second part of the activity, students vary the charges of the particles. This leads to the writing of Coulomb's law.



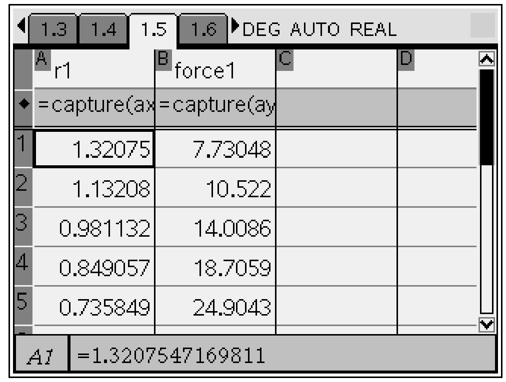


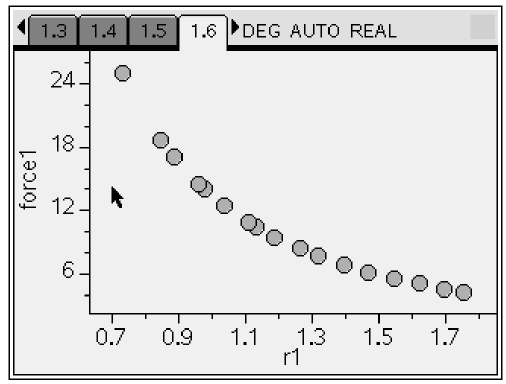
Step 1: Students should open the file **PhysBR_week27_charge-distance.tns** and read the first two pages. Page 1.3 shows two positively charged particles separated by a distance *r*. Students should drag the smaller particle to vary the separation between the two charged particles. To drag the particle, students should use the NavPad to move the cursor until it is above the small particle. They should press and hold until the cursor changes to a closed hand. They can then use the NavPad to drag the particle. Then, they should answer question 1.

Q1. Describe how *F* changes as *r* changes.

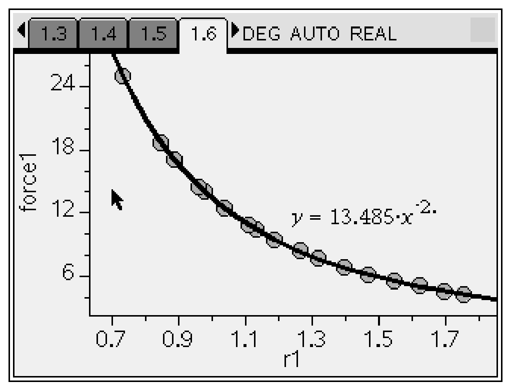
A. F *increases as* r *decreases.*

Step 2: Next, students should return to page 1.3 and do a manual capture of force and distance data as they drag the small particle. To capture a data point, students should press ctrl . . Students should capture at least 10–15 data points. The data will be stored in the spreadsheet on page 1.5. On page 1.6, students should make a graph of **force1** vs. **r1**. To make the plot, students should click (press) on the area just below each axis. A list of available variables will pop up. They should choose **r1** for the *x*-variable and **force1** for the *y*-variable. Alternatively, they can add the *x*- and *y*-variables using the **Plot Properties** menu (**Menu > Plot Properties > Add X Variable** or **Add Y Variable**).





Step 3: After students have made the plot, they should use the **Power Regression** tool (**Menu > Analyze > Regression > Show Power**) to find a power regression that fits the data. Then, they should answer questions 2 and 3.

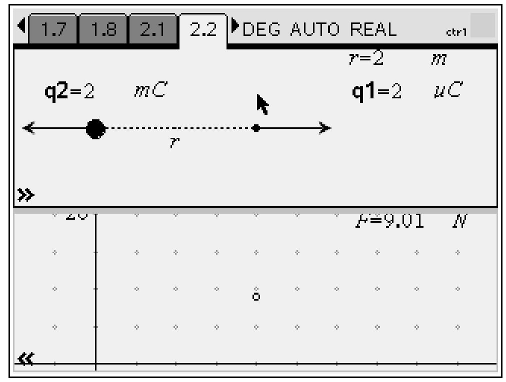


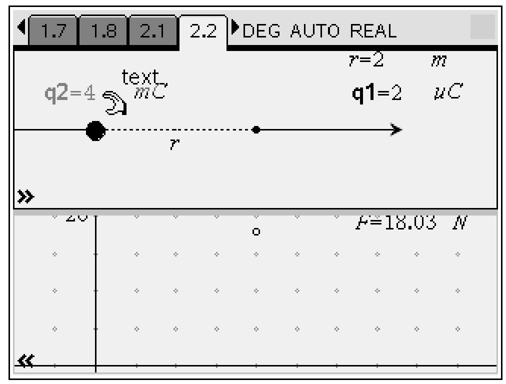
Q2. Write the equation for electrical force (*F*) as a function of distance (*r*).

A. $F = \frac{13.485}{r^2}$

Q3. What type of relationship is this? What are some other phenomena that show a similar relationship?

A. *It is an inverse-square relationship. Encourage student discussion of other inverse-square phenomena, such as gravitational force vs. distance and light intensity vs. distance.*





Step 4: Next, students should move to page 2.1 and read the text there. Then, they should move to page 2.2, which shows two positively charged particles separated by a distance *r*. In this simulation, students can vary the charges of both particles (**q1** and **q2**). Students should vary **q1** and **q2** and observe the effects on *F*. (To change the value of a charge, they should double-click on it, delete the existing value, type in the new value, and press [enter].) Then, they should answer questions 4–8.

Q4. If **q1** is doubled, from +1 to +2 μC, what is the effect on the force?

A. *The force doubles.*

Q5. Describe how doubling **q1** would affect the equation relating *F* and *r*.

A. *The value of the constant would change, but the functional form would remain the same—that is, it would still be an inverse-square relationship.*

Q6. If the charges on both particles are doubled, what is the effect on the force?

A. *The force increases by a factor of four.*

Q7. What do these data indicate about the relationship between the charges on two particles and the electrical force between them?

A. *The data suggest that force is proportional to the product of the charges. Encourage students to discuss why this must be the case.*

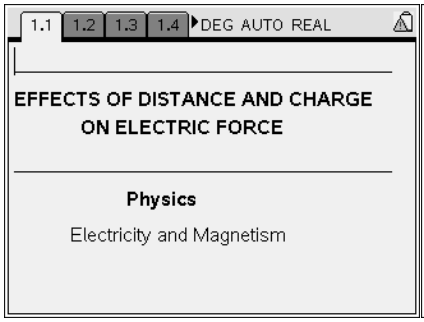
Q8. Write an equation for electrical force *F* in terms of q_1, q_2, and *r*. Let the constant of proportionality be *k*.

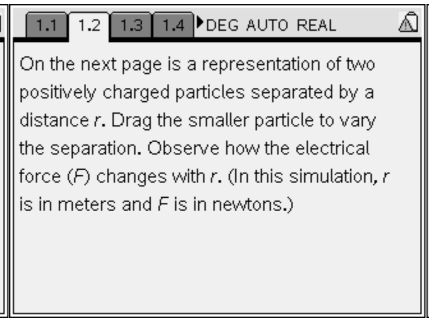
A. $F = k\frac{q_1 \bullet q_2}{r^2}$ *; encourage student discussion on how to derive this equation.*

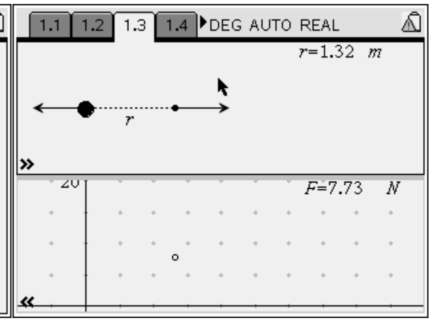
Ideas for Extension Activities: If you wish, you may have students use the simulations to solve for the value of *k*. You may wish to extend this activity by having students use charge sensors to determine the relationship between charge, electric force, and distance.

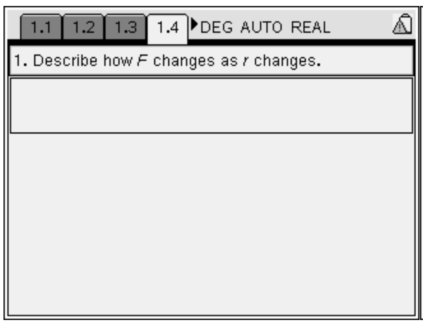
Bell Ringer: Effects of Distance and Charge on Electric Force – ID: 13709

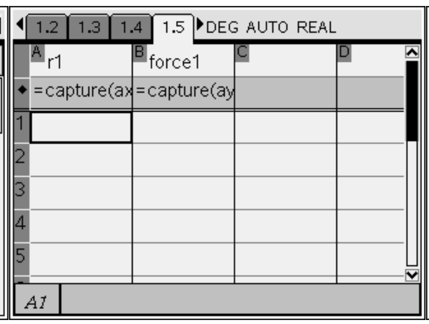
(Student)TI-Nspire File: *PhysBR_week27_charge-distance.tns*

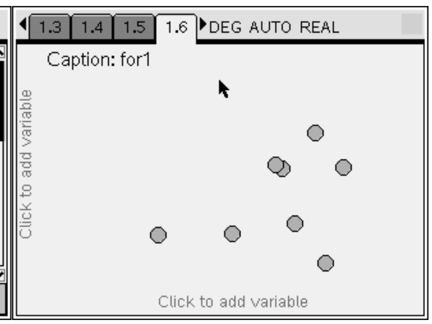


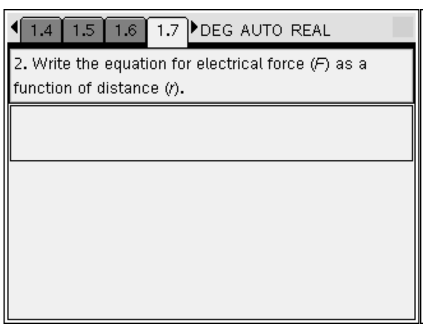


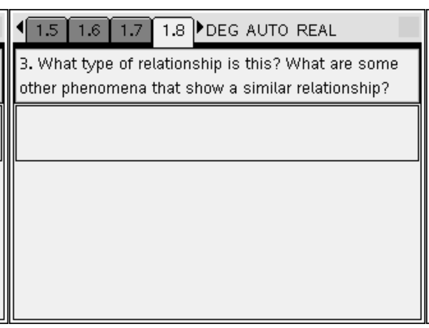


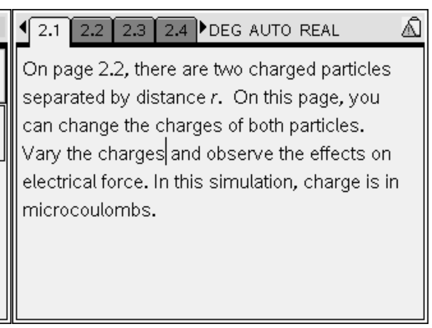


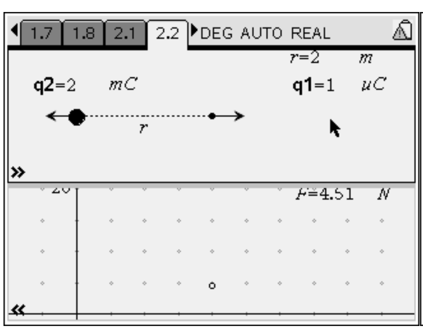


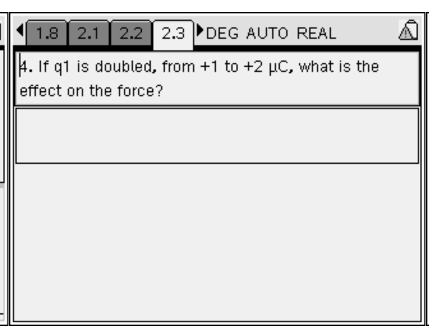


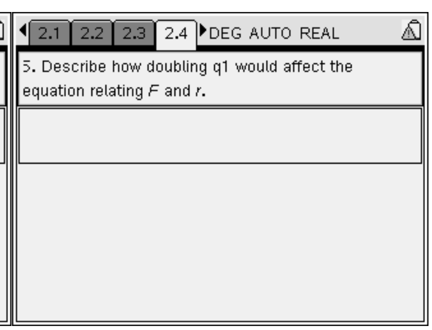


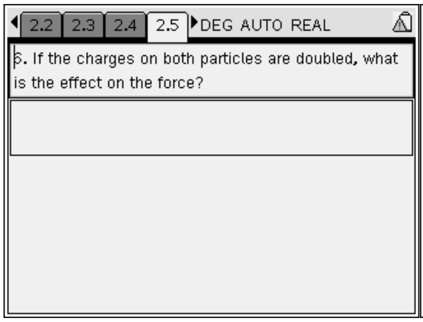


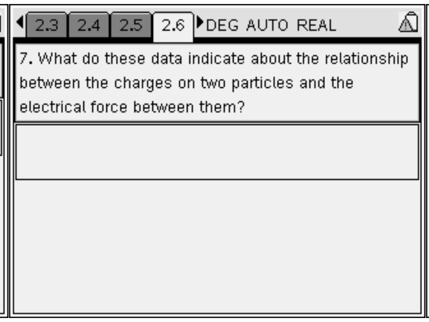


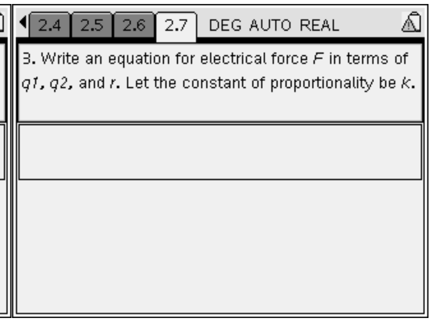







2.2 2.3 2.4 2.5 DEG AUTO REAL
6. If the charges on both particles are doubled, what is the effect on the force?


2.3 2.4 2.5 2.6 DEG AUTO REAL
7. What do these data indicate about the relationship between the charges on two particles and the electrical force between them?


2.4 2.5 2.6 2.7 DEG AUTO REAL
8. Write an equation for electrical force *F* in terms of *q1*, *q2*, and *r*. Let the constant of proportionality be *k*.

