Science Objectives

- Students will explore the electric force between charged objects.
- Students will observe how the force depends upon the magnitude of the two charges and the distance separating them.

Vocabulary

- attract
- charge
- distance
- force
- magnitude
- Newton (used as a unit)
- ratio of forces
- repel

About the Lesson

- This lesson has students explore Coulomb's law by manipulating the magnitude of two charges and the distance separating them.
- As a result, students will:
  - Observe that charges with like signs repel and charges with opposite signs attract.
  - Relate the magnitude of the force the charges exert on each other to the product of the two charges and to the inverse square of the distance separating them.

TI-Nspire™ Navigator™

- Send out the *Moving_Objects_Electrically.tns* file.
- Monitor student progress using Class Capture.
- Use Live Presenter to spotlight student answers.
- Collect the student .tns file and evaluate student understanding.

Activity Materials

- Compatible TI Technologies: TI-Nspire™ CX Handhelds, TI-Nspire™ Apps for iPad®, TI-Nspire™ Software

Tech Tips:

- This activity includes class captures taken from the TI-Nspire CX handheld. It is also appropriate for use with the TI-Nspire family of products including TI-Nspire software and TI-Nspire App. Slight variations to these directions may be required if using other technologies besides the handheld.
- Watch for additional Tech Tips throughout the activity for the specific technology you are using.
- Access free tutorials at http://education.ti.com/calculators/pd/US/Online-Learning/Tutorials

Lesson Files:

Student Activity

- Moving_Objects_Electrically_Student.doc
- Moving_Objects_Electrically_Student.pdf

TI-Nspire document

- Moving_Objects_Electrically.tns

Discussion Points and Possible Answers

Allow students to read the background information on their student activity sheet.

Move to page 1.2.

1. This page gives students some background and some instructions for the simulation on page 1.3. On the simulation page, students will use minimized sliders to set the amount and sign of the charge on each of the two balloons. Students will also be able to change the position of each balloon. In this simulation, attractive forces are designated with a negative sign, and repulsive forces are designated with a positive sign.

Move to page 1.3.

2. Using this simulation, students will set up several different scenarios and record the force between the charges in each case. They will then compute the ratio of the force in a particular scenario to a standard value designated as F_1. The ratios should help students understand how the force depends on both the values of the charges and the distance separating them.

Have students answer Questions 1 - 19 on their student activity sheet. *(A few questions are included at the end on pages 1.5 through 1.8 in the .tns file as a review.)* Students should complete the questions on the activity sheet first.

Q1. With both balloons having zero charge, press the play button. What is the force between the two balloons?

Suggested Answer: There is no force on either balloon and no movement.

Q2. Select the reset button ( ). Give Balloon 1 a +5 charge and leave Balloon 2 as is. Select play and describe what happens. Repeat with a –5 charge. Describe what happens.

Suggested Answer: There is no force on either balloon and no movement.

Q3. Select the reset button ( ). Now give Balloon 1 a +1 charge and do the same for Balloon 2. What is the electric force between the balloons? What happens when you press play?

Suggested Answer: 0.4 N; the balloons move away from each other

Q4. The dashed arrow that appears next to each balloon is an indication of the electric force. What happens as you increase the charge on each balloon from +1 to +5?

Suggested Answer: The size of the arrow increases.

Q5. Now give both Balloon 1 and Balloon 2 a –1 charge. What is the electric force between the balloons? What happens when you press play? What happens as you increase the charge?

Suggested Answer: The balloons repel each other with an increasingly stronger force.

Q6. Describe the directions of the forces when both balloons have the same type of charge.

Answer: They move away from each other.

Q7. Give both balloons a charge of +1. Separate the balloons by a distance of 1 m. Record the magnitude of the force. In the next several questions, you will compare other forces to this one.

Answer: F_1 = 0.9 N

Q8. Change the charge of Balloon 1 to +2. Record the new force as F_2. Calculate the ratio of F_2:F_1.

Answer: F_2 = 1.8 N; $\frac{F_2}{F_1} = 2$ Doubling one charge doubles the force.

Q9. Change the charge of Balloon 2 to +2. Record the force as F_3. Calculate the ratio of F_3:F_1.

Answer: F_3 = 3.6 N; $\frac{F_3}{F_1} = 4$ Doubling both charges quadruples the force.

Q10. Give Balloon 1 a charge of –3, and give Balloon 2 a charge of +4. Record the force as F_4 and calculate the ratio of F_4:F_1.

Answer: F_4 = –10.78 N; $\frac{F_4}{F_1} = -12$

Q11. Based on your observations in the previous questions, summarize the relationship between the magnitude of the force and the values of the charges.

Suggested Answer: The force is proportional to the product of the two charges.

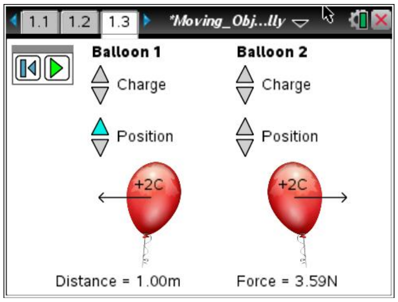
Q12. Change the charge on both balloons back to +1. Move the balloons so that the separation between them is 2.0 m (twice the original distance). Record the force as F_5, and calculate the ratio F_5:F_1.

Answer: F_5 = 0.22 N; $\frac{F_5}{F_1} = \frac{1}{4}$

Q13. Move the balloons so that the distance between them is now 3.0 m (three times the original distance). Record the force as F_6 below, and calculate the ratio F_6:F_1.

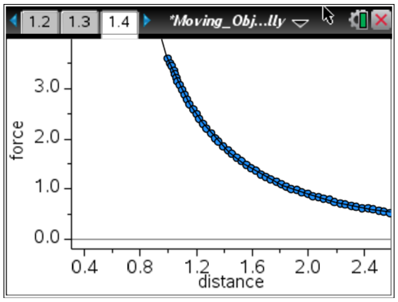
Answer: F_6 = 0.10 N; $\frac{F_6}{F_1} = \frac{1}{9}$

3. Now have students reset the simulation and change the charge on each balloon to +2 and the distance between them to 1 m. They are to try to get their screen to look like the one at the right. Then press the play button.



Move to page 1.4.

4. Students will see the graph that is displayed to the right.



Q14. What two variables are graphed?

Suggested Answer: distance and force

Q15. What is the relationship between these two variables?

Suggested Answer: As the distance between the balloons increases, the force between them decreases.

Q16. Is this a linear graph or a nonlinear graph? How can you tell?

Answer: A nonlinear graph because it does not form a straight line.

Q17. What happens to the force between the balloons as they move apart? How is this shown on the graph?

Answer: The force decreases. The graph dips down for increasing values of distance.

Q18. Return to the simulation on page 1.3. Select the reset button to clear the data. Give Balloon 1 a charge of +2 and Balloon 2 a charge of –2. Set the distance to 2.3 m. Select play and then immediately switch to page 1.4. Describe the graph.

Answer: It has the same shape as the previous graph but the points are moving upward.

TI-Nspire™ Navigator™ Opportunities

Make a student a Live Presenter and have them demonstrate how to calculate the constant.

Q19. What happens to the electrical force between the balloons as they come closer together? How is this shown on the graph?

Answer: The force increases. The graph goes up for decreasing values of distance.

Move to page 1.5.

After students answer the questions on this activity sheet, have them answer the questions on pages 1.5 – 1.8 in the .tns file to review what they have learned.

Extension

Have students make up their own problems using the simulation to practice using Coulomb's law. Students may also need more practice using proportions to determine how much the force changes when changes are made in either of the charges or in the distance separating them.

Wrap Up

You can have students answer the questions in the .tns file as additional reinforcement and review. When students are finished with the activity, pull back the .tns file using TI-Nspire Navigator. Discuss activity questions using Slide Show.

Assessment

- Formative assessment will consist of questions in the activity sheet and the .tns file. The questions will be graded when the .tns file is retrieved. The Slide Show will be utilized to give students immediate feedback on their assessment.
- Summative assessment will consist of questions/problems on the chapter test.