



### Science Objectives

- Students will explore the concept of electric fields near point charges.
- Students will observe and describe the patterns of the electric fields surrounding a single positive charge, a single negative charge, two positive charges, and two charges with opposite signs.

### Vocabulary

- electric field
- charge
- electric field lines

### About the Lesson




- This lesson simulates electric fields near point charges. The first problem explores the electric field near a single positive or a single negative charge. The second problem explores the electric field near two identical positive charges. The third problem explores the electric field near two opposite charges. The second and third problems allow students to leave images of the electric field vector on the screen to build up patterns.
- Students will:
  - Identify factors which affect the magnitude of the electric field.
  - Describe the patterns related to the direction of the field in each scenario.



### TI-Nspire™ Navigator™

- Send out the *Electric\_Fields.tns* file.
- Monitor student progress using Class Capture.
- Use Live Presenter to spotlight student answers.

### 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

- Electric\_Fields\_Student.doc
- Electric\_Fields\_Student.pdf

#### TI-Nspire document

- Electric\_Fields.tns



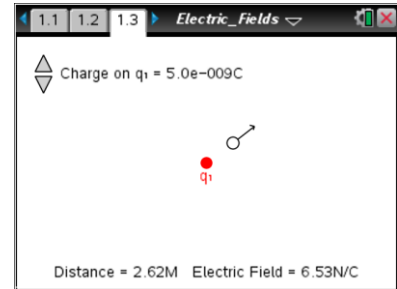
### Discussion Points and Possible Answers


Move to page 1.2.

Students should read the background material on this page.

Move to page 1.3.

- Students should drag the point around the screen. They should pay attention to the direction of the arrow, as well as the magnitude of the electric field displayed on the screen. The distance between the point and the charge is also displayed. Students should follow the directions and answer the questions on the handout.



**Tech Tip:** To access the Directions again, select  > **Electric Fields > Directions.**



**Tech Tip:** To access the Directions again, select menu or **Document Tools** () > **Electric Fields > Directions.**

Have students use the simulation to answer the following questions on the activity sheet.

- Set the charge,  $q$ , to  $+5 \text{ nC}$ . Drag the point with the arrow around the screen. Describe the patterns you see in the electric field. In what direction does the field point? How does the magnitude of the field change as the distance between the point and the charge changes?

**Sample Answer:** The field always points directly away from the charge (radially outward). The field is very strong near the charge and is much weaker far from the charge. The magnitude of the field diminishes quickly as the point gets farther from the charge.



**iPad Tip:** Have students tap on the arrows to change the values of the charge.

- Double the magnitude of the charge so that it is  $+10 \text{ nC}$ . What effect does this have on the magnitude of the electric field?

**Sample Answer:** The magnitude of the field doubles also.



- Q3. Move the point so that it is approximately 2.00 m away from the charge, and record the magnitude of the electric field. Now move the point so that it is approximately 4.0- m away, and record the new magnitude of the electric field. By what factor does the electric field change when the distance is doubled?

**Sample Answer:** The magnitude of the electric field decreases by a factor of 4.

- Q4. Move the point so that it is approximately 6.00 m away from the charge. Record the magnitude of the electric field and compare this to the magnitude when the point is 2.00 m away. By what factor does the electric field change when the distance is tripled? What relationship does this suggest between the magnitude of the electric field and the distance from the charge?

**Sample Answer:** The magnitude of the field decreases by a factor of 9. This implies that the magnitude of the electric field is inversely proportional to the square of the distance from the charge.

- Q5. Change the charge so that it is a negative charge. How does this affect the electric field vector? Move the point around the screen and describe the pattern of the electric field near a negative charge.

**Sample Answer:** The vector now points directly toward the charge. At every point on the screen, the vector points toward the charge (radially inward). The field is weak far from the charge and very strong near the charge.

### Move to pages 1.4 – 1.6.

Have students answer the questions on either the device, on the activity sheet, or both.

- Q6. The electric field vector near a single point charge always points \_\_\_\_\_.

**Answer:** C. directly away from a single positive charge and directly toward a single negative charge

- Q7. The magnitude of the electric field near a single point charge is \_\_\_\_\_.

**Answer:** B. directly proportional to the magnitude of the charge

- Q8. The magnitude of the electric field near a single point charge is \_\_\_\_\_.

**Answer:** D. inversely proportional to the square of the distance from the charge

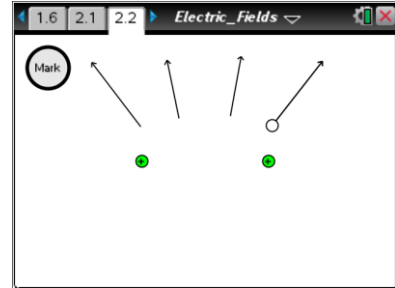



Move to page 2.1.

Students should read the background information about this simulation.


Move to page 2.2.

- This page simulates the electric field near two positive charges. Students should use the Mark button to leave will leave a copy of the vector on the screen. Encourage them to look for patterns in the field.



**Tech Tip:** To clear the electric field, select  > **Electric Fields** > **Clear Field.**



**Tech Tip:** To clear the electric field, select menu or **Document Tools** () > **Electric Fields** > **Clear Field.**

Have students use the simulation to answer the following questions on the activity sheet.

- Describe the overall pattern you observe of the electric field surrounding the two positive charges.

**Sample Answer:** The field generally points away from the two charges. On the left and right sides of the screen, the field looks much like the field near a single positive charge. Between the two charges the field is weak. Above the charges the field points up, and below the charges the field points down.



### TI-Nspire Navigator Opportunities

Make a student a Live Presenter to demonstrate the pattern of vectors they created.

- Where is the electric field the strongest?

**Sample Answer:** The field is strongest very near the charges. Just to the left of the left charge and just to the right of the right charge are the points of maximum magnitude.

- Where is the electric field the weakest?

**Sample Answer:** The field is weakest far from the charges and near the midpoint between the charges.



Q12. What do you observe when you place the point mid-way between the two charges? How much force would a charge placed at this position experience?

**Sample Answer:** The electric field is zero at the midpoint. A charge placed here would experience no force acting on it.

Q13. Imagine a line drawn from the top to the bottom of the screen which passes through the midpoint between the charges. Move the point along this line and describe the direction of the electric field along it.

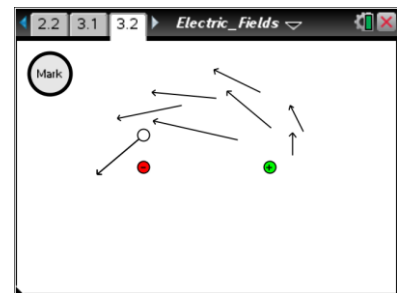
**Sample Answer:** The field is oriented vertically. Above the charges the field points upward, and below the charges it points downward.

**Move to page 3.1.**

Students should read the instructions for the next page.

**Move to page 3.2.**

3. The left charge is positive and the right charge is negative, but they have the same magnitude. Students drag the test point and select the Mark button at regular intervals to leave an image of the vector and build up a pattern of the electric field.



Have students use the simulation to answer the following questions on the activity sheet.

Q14. Describe the overall pattern you observe of the electric field surrounding the two positive charges.

**Sample Answer:** On the left side of the screen the field points away from the positive charge. On the right side to the screen the field points toward the negative charge. Between the two charges, the field points from the positive to the negative charge.



### TI-Nspire Navigator Opportunities

Make a student a Live Presenter to demonstrate the pattern of vectors they created.

Q15. Where is the electric field the strongest?

**Sample Answer:** The field is strongest between the two charges.



Q16. Where is the electric field the weakest?

**Sample Answer:** The field is weakest far from the two charges.

Q17. Describe the electric field between the charges.

**Sample Answer:** The field is very strong between the charges. It points from the positive charge toward the negative charge.

Q18. Imagine a line drawn from the top to the bottom of the screen which passes through the midpoint between the charges. Compare and contrast the field on the left side of this line with the field on the right side of the line?

**Sample Answer:** On the left side of the line, the field is always pointing away from the positive charge. On the right side of the line, the field is always pointing toward the negative charge. The fields appear to mirror each other on either side of the line in every respect except the direction of the arrows.

Q19. Electric field lines are drawn as smooth, continuous curves which begin on positive charges and end on negative charges. The lines never cross one another. The lines are drawn close together where the field is strong and farther apart where it is weaker. Using the patterns you have observed in this activity, sketch the electric field lines near a single positive charge, a single negative charge, two positive charges, and two charges with opposite signs.

**Sample Answer:** Student sketches will vary, but guide students toward the standard representations of electric fields found in most physics textbooks.



### TI-Nspire Navigator Opportunities

Throughout the lab, discuss the activity with students using Slide Show. At the end of the lab, collect the .tns files and save to Portfolio.

## Wrap Up

When students are finished with the activity, pull back the .tns file using TI-Nspire Navigator and collect student handouts. Discuss activity questions using Slide Show.



### Assessment

- Formative assessment will consist of questions embedded in the .tns file and student responses on the Electric\_Fields\_Student document. 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.