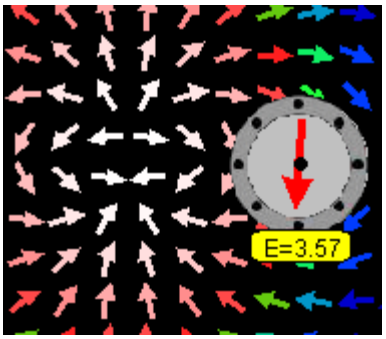


Screen shot of simulation showing a dipole and electric field detector.

Worksheet: Electric Multipole Simulation

Key Topic/Concept: Electric Field

Materials:

- One guide sheet for each student
- Computer with simulation downloaded
- Science Notebook

The EJS Electric Multipole simulation can be downloaded from the comPADRE National Digital Library if it not available on the local computer:
< http://www.compadre.org/OSP/items/detail.cfm?ID=9683>

Safety Precautions: No special precautions needed for this lesson.

Written by: Anne J Cox
Edited by: Mario Belloni and Wolfgang Christian

Physics Classroom Curriculum Alignment:

Static Electricity- Lesson 4: Action-at-a-Distance
Static Electricity- Lesson 4: Electric Field Intensity

NC Curriculum Alignment (2004):

1.05 Analyze evidence to:

- Explain observations.
- Make inferences and predictions.
- Develop the relationship between evidence and explanation.

1.08 Use oral and written language to:

- Communicate findings.

- Defend conclusions of scientific investigations.

1.09 Use technologies and information systems to:

- Research.
- Visualize data.

8.01 Analyze the nature of electrical charges.

- Investigate the electrical charging of objects due to transfer of charge.
- Investigate the conservation of electric charge.
- Analyze the relationship among force, charge and distance summarized in Coulomb's law.

I. ENGAGEMENT/REVIEW

Review the idea of electric fields. Complete as a whole group with a fast pace (about 15 minutes) and with students using their science notebooks.

An electric field is _____.
Sketch your prediction of the field vectors of a dipole (defined as a positive and a negative charge).

II. EXPLORATION

Have students work in pairs and open the EJS Coulomb Force simulations. Allow students about 5 minutes to explore with the simulation.

III. EXPLANATION/CONCEPT INVENTION

Ask students to reset the simulation begin with questions in the guide below. When most students have completed the guide, review the answers with the whole group.

IV. EXPANSION OF THE IDEA

Ask students to write a brief description or make sketches to explain the motion observed.

V. EVALUATION

Teacher circulates to check that the Introduction and Coulomb Force Worksheet is completed and stapled into the science notebook.

Introduction: Electric Field

An electric field is _____
_____

The configuration below is a dipole: one positive and one negative charge. Sketch what you think the electric field vectors will look like for this dipole:

Activity Guide: EJS Electric Multipole Simulation

In this simulation, you can change the initial configuration (monopole, dipole, quadrupole) and change the amount of charge on the charges.

1. Run the Applet file on-line OR run the simulation by double-clicking on the ejs_electric_sampler.jar and then navigating to the Coulomb Pendulum simulation and run the simulation by double-clicking on the green arrow.
2. Run the simulation of a monopole (point charge) at the origin. Move the detector around in the electric field and observe the value of the electric field. When the detector is moved twice as far from charge, what happens to the electric field (Record Data if you need to)? Is this consistent with the equation for the electric field of a point charge: $E=kq/r^2$?

   _____

   _____

3. Now, try the dipole simulation. A dipole is constructed of two charges: a positive and negative charge near each other centered at the origin. In what direction is the dipole oriented? Draw a sketch below.

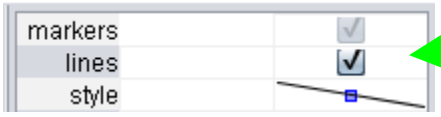
   How do you know?

   _____

4. A quadrupole is constructed from four charges or two dipoles (pointing in opposite directions). Can you tell how the charges are arranged? Draw a sketch or explain.

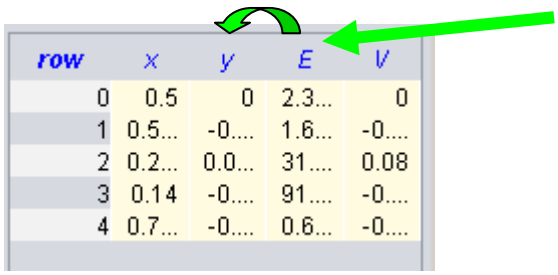
Optional Quantitative Analysis:

5. How does the electric field decrease as you move away from the origin along the x-axis (*1/x, 1/x^2, 1/x^3, 1/x^4*)? To find out, move the **detector along the positive x-axis (keeping y=0)** and record the field values in the Data Table. Then try to find a good fit for the data by clicking on the Wrench ( ) button and using the DataTool. Some notes on working with the DataTool:
   a. DataTool automatically draws lines between nearby points and you may find this confusing. Click on the checkbox with a line through it (above the data) to remove the connecting lines.



uncheck this

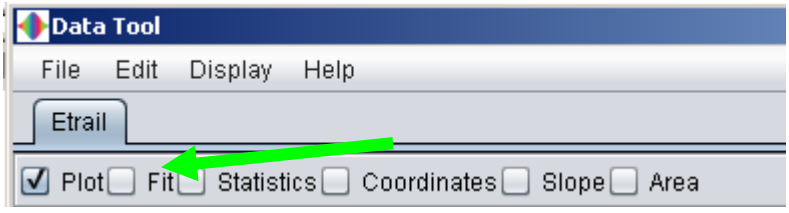
   b. If you want DataTool to Fit the data, you first need to pick the data to Fit. DataTool will fit the first two columns of data so to have it fit E as a function of x, you need to move the E column to the vertical axis.



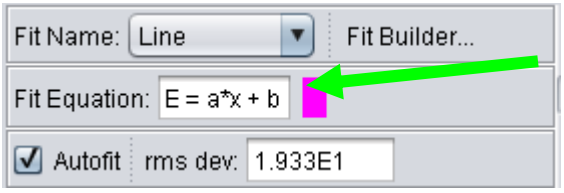
row	x	y	E	V
0	0.5	0	2.3...	0
1	0.5...	-0....	1.6...	-0....
2	0.2...	0.0...	31....	0.08
3	0.14	-0....	91....	-0....
4	0.7...	-0....	0.6...	-0....

Click and drag this column to the second column

   Then, click the Fit checkbox.

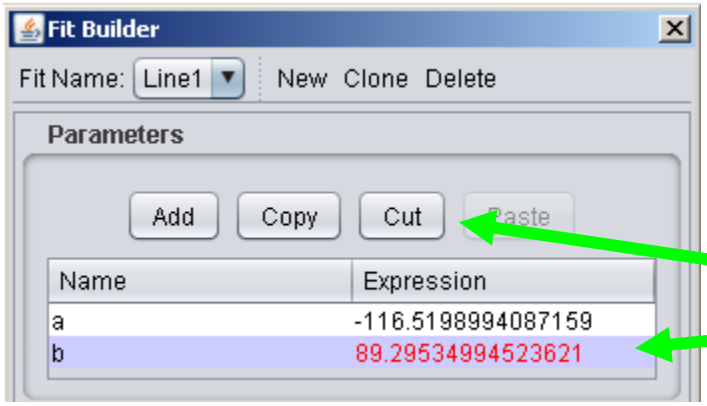


c. Since the electric field decreases as you get further way, you will need to try an equation not in the list by editing the current equation in `Fit Builder`. For example, if you want to fit the data to a/x^3 (and have the program automatically find the value of a), first, double-click on the equation of the line (E=a*x+b)



double-click to edit

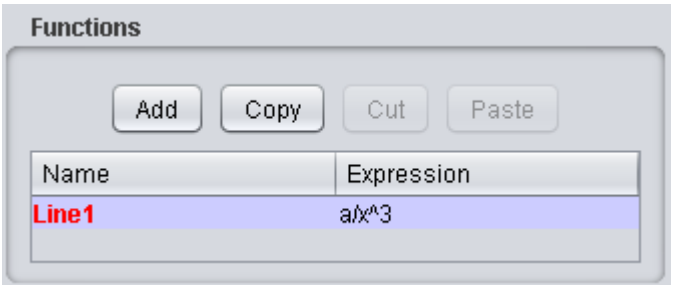
d. This to automatically opens the `Fit Builder`. In this case, since you only want to fit one parameter, first delete parameter "b" (from the parameter list)



(you may need to increase of the size of window if you don't see both a and b)

Click to select b and then use "cut" button

and then type your new `Line1 = a/x^3` in the equation box.



e. Try E = a/x, E=a/x^2, E=a/x^3, E=a/x^4 …Which is the best fit? Describe your method for determining best equation for each configuration (monopole, dipole and quadrupole):

_____
_____
_____
_____

Configuration	Best Equation (E=a/x, a/x^2, a/x^3….)	a	rms deviation
Monopole			
Dipole			
Quadrupole			

6. Following this trend, then, what dependence would you expect for an octopole (two quadrupoles)?

_____