Coulomb’s Law - Electric Force between Two Charges

A Virtual Simulation Lab

INTRODUCTION

Electrostatic labs are difficult to do because we are unable to actually “see” or “hold” an electric charge. This virtual lab will provide some visual experience as you work through problems involving the force between two charged particles. You will be able to see the effects on the resulting force when changing the sign and the magnitude of the charges as well as changing the distance between the charges. The simulation will calculate the force automatically for you, but as part of the lab, you will complete the calculation as well and show your work.

PROCEDURE I – Repulsive or Attractive Forces

1. Open the simulation: <https://phet.colorado.edu/en/simulations/coulombs-law>

Push the play button on the video window

Select “Macro Scale”

1. The simulation opens with two charges held in place by two stick figures:
   1. Click to “Uncheck” the box labeled “Force Values”
   2. Click and grab the left charge and position its center at the 3 cm mark on the ruler
   3. Click and grab the right charge and position its center at the 7 cm mark on the ruler
   4. These positions will remain the same throughout Procedure I
   5. Set the left charge to -4 C (it should be a negative or blue charge)
   6. Set the right charge to +8 C (it should be a positive or red charge)
   7. Study the resulting arrows representing the force on each charge. Would these forces be best described as “attractive” or “repulsive”? Attractive
2. Now change the signs of the charges
   1. Set the left charge to +8 C (it should now be a positive or red charge)
   2. Set the right charge to -4 C (it should now be a negative or blue charge)
   3. Study the resulting arrows representing the force on each charge. Would these forces be best described as “attractive” or “repulsive”? Attractive
   4. What general statement could be made about the direction of the force between two opposite charges?

The forces are directed towards each other.

1. Now change the sign of just ONE the charges
   1. Set the left charge to +8 C
   2. Set the right charge to +4 C
   3. Study the resulting arrows representing the force on each charge. Would these forces be best described as “attractive” or “repulsive”? Repulsive
2. Now change the sign of BOTH the charges
   1. Set the left charge to -8 C
   2. Set the right charge to -4 C
   3. Study the resulting arrows representing the force on each charge. Would these forces be best described as “attractive” or “repulsive”? Repulsive
   4. What general statement could be made about the direction of the force between two like charges?

The forces are directed away from each other

PROCEDURE II – Electric Force and Charge Separation

1. Be sure the center of your charges are now directly over the 3 cm and 7 cm mark.
   1. Use simple subtraction and record the separation between the charges. r = 4 cm
   2. Now click and Check the box labeled as Force Values
   3. Record the magnitude of the force value between the charges (it is same for both) F = 179.751 N
2. Now move the charges to half the distance by placing them over the 4 cm and 6 cm marks
   1. Use simple subtraction and record the separation between the charges. r = 2 cm
   2. Record the magnitude of the force value between the charges (it is same for both) F = 719.004 N
   3. Determine by what ratio the force increased by dividing force 7b by force 6c A ratio of 4
   4. Show work below:

719.004 N / 179.751 N = 4

* 1. Complete the statement: When the distance between two charges decreases by half, the force between the two charges increases by 4 times

1. Now let’s determine for the same two charges in part 7, how do we need to change their separation distance in order to REDUCE the force by a factor of 9x.
   1. First, let’s determine what the force is when reduced by a factor of 9X. To do this, divide force 7b by 9. The result is F = 79.889 N
   2. Now click and drag the charges apart until the force displayed is equal to the value in 8a. Hint: you’ll probably need to drag both charges to get enough separation.
   3. Positions for 9X force reduction; Left charge 0 cm, Right charge 6 cm
   4. Charge separation for 9X force reduction; r = 6 cm
   5. Determine the ratio for the change in separation by dividing 8d by 7a: Ratio = 3
   6. Complete the following statement: The force between two charges decreases by a factor of 9X when the distance between two charges increases by 3 times
2. Check your statements in 7e and 8f. Do they both agree with Coulomb’s Law in that the Force (F) is proportional to the separation distance (r) by ? Yes or No

PROCEDURE III – Electric Force and Charge Magnitude

1. Return the charges to the original conditions:
   1. Left charge -4 C at 3 cm, Right charge +8 C at 7 cm
   2. Calculate the force between the charges using the value and the equation . Remember to convert all input values to SI units.

F = = 179.76 N

* 1. How does this value compare with the simulation Force Value? It is nearly identical.
  2. Now calculate the same force between the charges using the simpler value

F = = 180 N

* 1. Now determine the percent difference between the answers in 10d and 10b. 0.13%
  2. Do you think we are justified in this course to use in our calculations and make life a little easier? Yes

1. You may have noticed in Coulomb’s Law , that BOTH charges are used in the calculation regardless of WHICH force we are calculating (i.e. on which charge). So we can say when calculating force (or using the simulation) that the MAGNITUDE of the Force on either charge is: Always the same force on both charges OR Sometimes different forces on the different charges Always the same force on both charges
2. Changing charge magnitude:
   1. Use your result from 10b to predict the Force between the charges if the Left charge was reduced by a factor of 2 (from -4 C to – 2 C). Do perform the complete calculation again, but instead simply change the answer to 10b by the appropriate amount. F = 90 N
   2. Check your result with the simulation. Does it match? Yes OR No
   3. Now use your result from 10b to predict the Force between the charges if BOTH the Left and Right charges were reduced by a factor of 2. Again, do NOT perform the complete calculation, but instead simply change the answer to 10b by the appropriate amount. F = 45 N
   4. Once again, check your result with the simulation. Does it match? Yes OR No

PROCEDURE IV – Making Projections

1. Let’s get SMALL!
   1. Calculate the force between an electron () and a proton () that are separated by 52 pm (where the prefix p means ) using the value and the equation . Your answer may be really small. F = 8.53 x 10^-8 N
   2. Now click on the “Atomic Scale” icon on the layer toolbar of the simulation.
   3. Set up the problem described above. Be sure “Force Values” is checked. Does this force match your calculated value? Yes