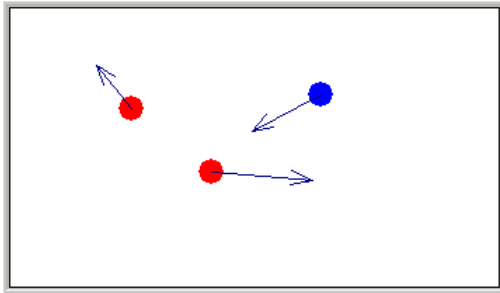


Electrostatics Worksheet

Part I: A. Charge and Interactions (from *Illustration 22.1 Physlet Physics*)



This animation allows you to add charges, move them around and see the force vectors between the charges. Use the text box for charge to add the charges. The arrows on the screen show how the particles interact with each other by showing both the magnitude (relative size of the arrow) and direction of the electrostatic force.

1. Use the animation to create three like charges at $x = -1$ m, $x = 0$ m, and $x = 1$ m. You can do this by entering the position in the text box and clicking the *add* button (**position is given in meters**). Sketch a diagram.
2. What is the net force on the middle charge?
3. Now move one of the outer charges around. Sketch your diagram.
4. Is the force on the middle charge still zero? Explain.
5. Push "reset" to clear the charges and set up two identical positive charges 1-m apart. Sketch your picture.
6. Move one charge toward the other and away from the other. What happens to the force between the two charges as you change the distance between the charges?

The force between two particles always lies on the line between the two particles, is attractive or repulsive depending on the signs of the charges, and varies as 1 over the square of the separation distance ($1/r^2$) (from Coulomb's Law).

7. Add a few charged particles with the same magnitude of charge (and with both positive and negative sign), and move them around by click-dragging them. Sketch a diagram of one of your configurations (with the force vectors).

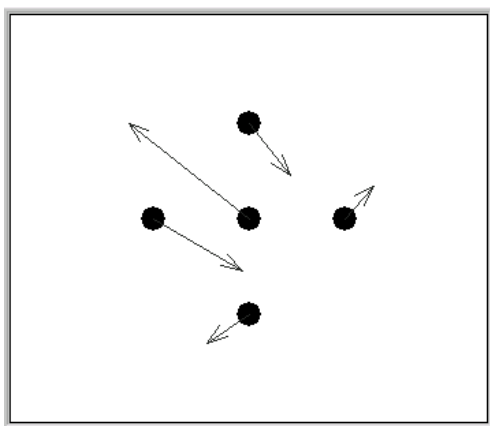
8. Now reset the animation and create two charges with different amounts of charge but of the same polarity (same sign: either both positive or both negative). Sketch a diagram and include the force vectors.

9. Describe the similarities and differences in the force vectors on each particle.

10. Reset the animation and create two charges of different magnitude and opposite polarity. Sketch a diagram including the force vectors.

11. Describe the similarities and differences in the force vectors on each particle.

Part I. B. Determining Charges (Problem 22.1, *Physlet Physics*)

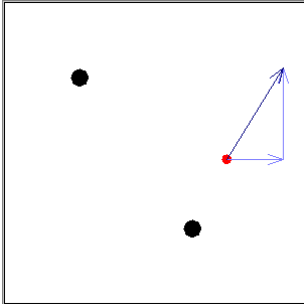


Five charged objects are shown on the screen along with vectors representing the forces on each object. You can click-drag on any object to change its position (**position is given in meters**).

1. Find two objects that repel each other and place them aside. Can you find any object that is attracted to one of these objects and repelled by the other? What does this observation tell you?

- How many charges are alike?

Part II. A. Ratio of Charges (from Exploration 22.1, *Physlet Physics*)



Two fixed charges and a draggable test charge are placed as shown (**position is given in meters and force is given in newtons**).

The blue arrow represents the force on the red test charge. The forces on the fixed charges are not shown. You can examine the forces with the [first](#) fixed charge, with the [second](#) fixed charge, or with [both](#) fixed charges in place. Notice that the net force on the test charge is displayed in the yellow message box when you have only one charge present but not when you have both charges present.

Answer the following questions with both fixed charges in place.

- Determine the net force on the test charge at the point (3 m, 4 m).

To do this, select [first](#) and read the force due to the "first" charge alone (magnitude and direction).

$F_{\text{red, first}} =$ _____, direction = _____

Next, do the same for the [second](#) charge.

$F_{\text{red, second}} =$ _____, direction = _____

- Now, sketch the two vectors represented by the forces in the usual "head to tail" vector addition picture and then give the resultant net force (this requires some math).

- Determine the net force on the test charge at a point midway between the two charges by first finding the midpoint and then measuring the magnitude of the force due to each charge ([first](#) and [second](#)) and also consider the direction.

First, you need to determine where the midpoint is:

$x_{\text{mid}} =$ _____ $y_{\text{mid}} =$ _____

Then, as in part (1) you will need to measure the magnitude of the force due to each charge (“first” and “second”) and also consider the directions.

4. Is (are) there any point(s) where the net force on the test charge is zero? If so, find those points.

Check this by moving the charge, but also think about it. How many such points are possible? Where should such “equilibrium” points be located when the charges are the same, opposite?

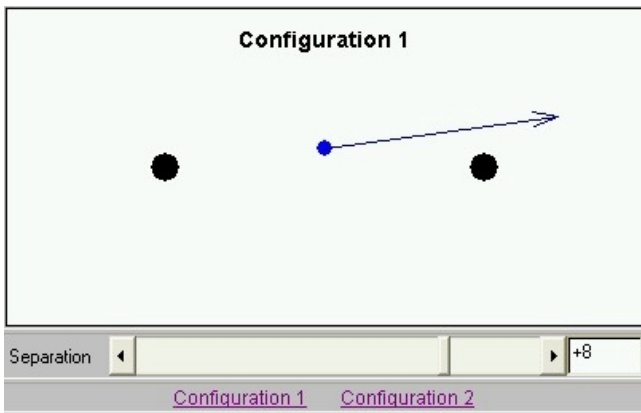
$x_{\text{equilibrium}} =$ _____ $y_{\text{equilibrium}} =$ _____

5. What is the ratio of the charges? (First charge is lower right)

Start with the test charge at the equilibrium point. Then, you will need to use Coulomb's law and also determine the distance to the equilibrium point from each charge. Also, what is the net force and the force due to each charge on the test charge at that point?

$$\frac{q_{\text{first}}}{q_{\text{second}}} =$$

Part II. B. Equilibrium (Problem 22.6, *Physlet Physics*)



In the animation there are two black fixed charges and a blue movable positive test charge (**position is given in meters and force is given in newtons**). The test charge has an attached arrow that indicates the direction and relative magnitude of the net electric force. The charge on the left is 25 times that of the right-hand charge. The initial separation is $d = 8.0$ m. Drag the test charge and note that the force is displayed in the yellow message box.

For **Configuration 1**,

1. There is a single point where the electric force on the test charge is zero. Find that point where the separation of the two fixed charges is 6 m.
2. Does the animation provide sufficient information to calculate the charge on the two black objects? If so, calculate the charge in coulombs.
3. Find an expression for the position of zero force for any value of the charge separation. Show that your result agrees with the animation.

Expression:

Check your equation:

Separation between charges	Calculated (x,y) position of $F=0$	$ F $ observed at that point?