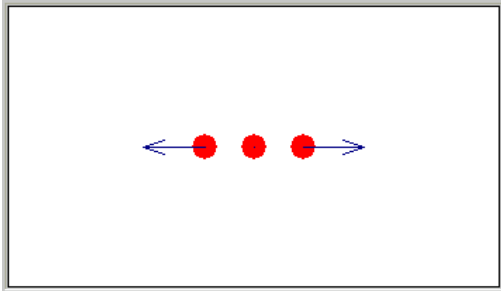


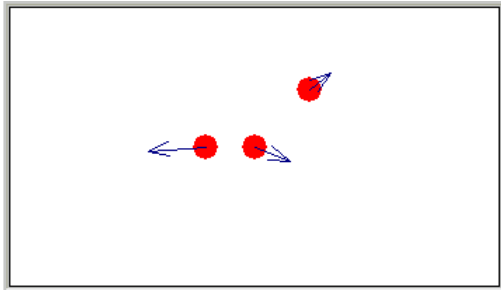
Electrostatics Worksheet

Part I. A. Charge and Interactions

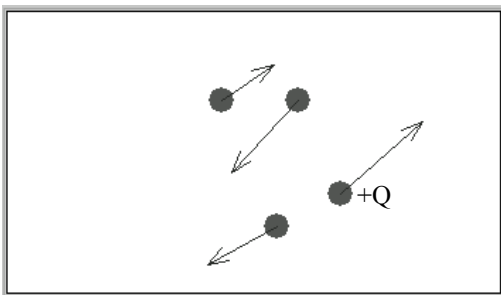
1. There are three like charges in a line in the diagram below. What is the net force on the middle charge (force vectors shown)?



2. Now suppose one of the outer charges is moved around. Is the force on the middle charge still zero? Explain.

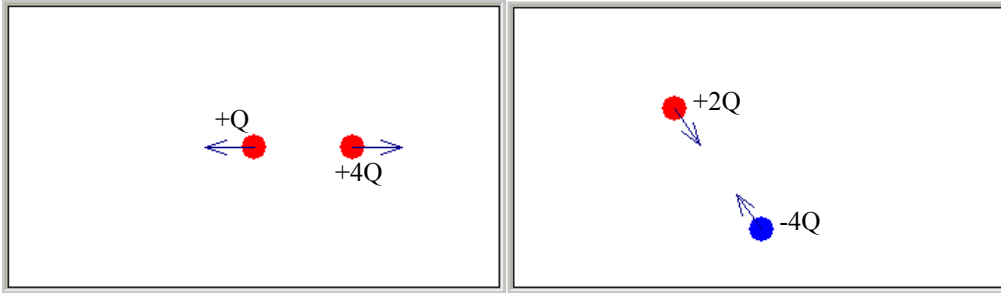


3. Here is a picture of a few charged particles with the same magnitude of charge (and with both positive and negative sign). The arrows show both the magnitude (by relative length of the vector) and direction of the force charge to add the charges. Label the rest of the charges as either positive or negative:



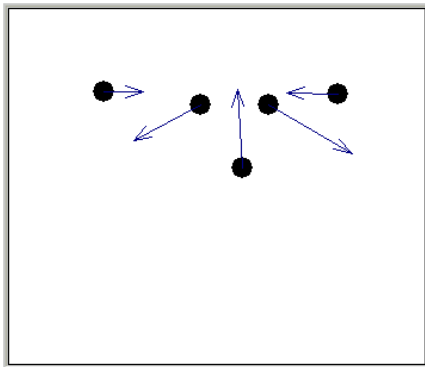
The force between two particles always lies on the line between the two particles, is attractive or repulsive depending on the signs of the charges, and varies as 1 over the square of the separation distance ($1/r^2$) (from Coulomb's Law).

4. Below (left) is a diagram of two charges of the same sign, but different magnitudes. What are the similarities and differences in the force vectors?



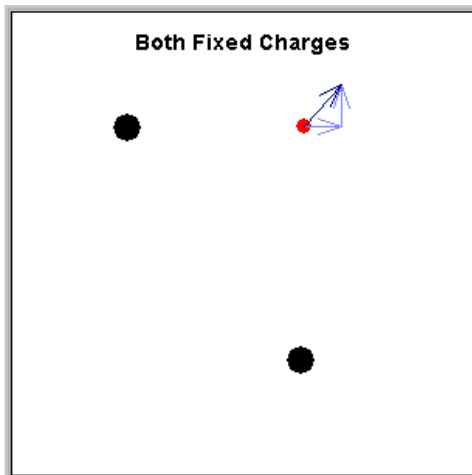
5. Above (right), the two charges have opposite polarity (one positive and one negative), but different magnitudes of charge. What are the similarities and differences in the force vectors?

Part I. B. Determining Charges

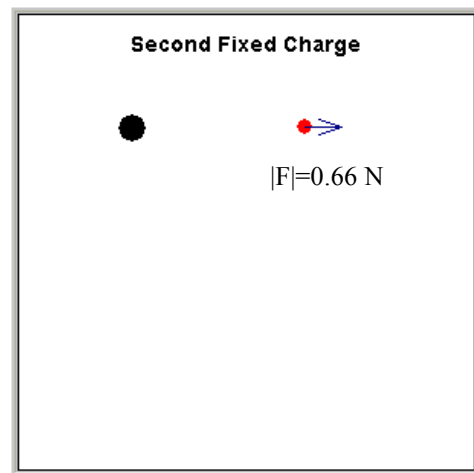
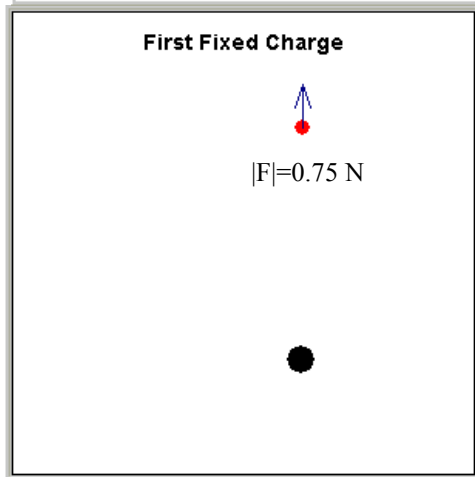


Five charged objects are shown on the screen along with vectors representing the forces on each object. How many charges are alike? (Mark the ones in the diagram that are the same.)

Part II. A. Ratio of Charges



Two fixed charges and a 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 when it is at (3 m, 4 m). One of the charges is at (3 m, 0 m) and the other is at (0 m, 4 m). Below is the force when an only one of the two charges is present:



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

To do this, first determine the force due to the “first” charge alone (magnitude and direction).

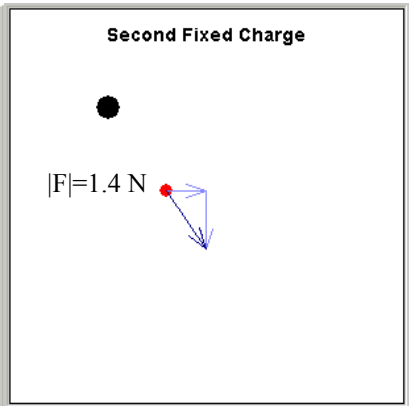
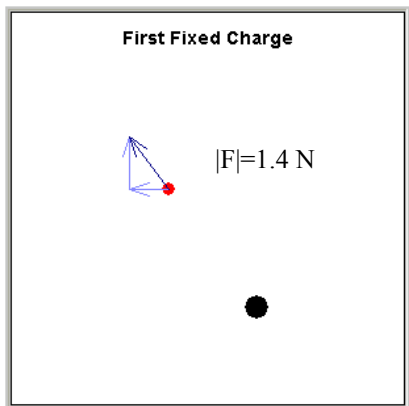
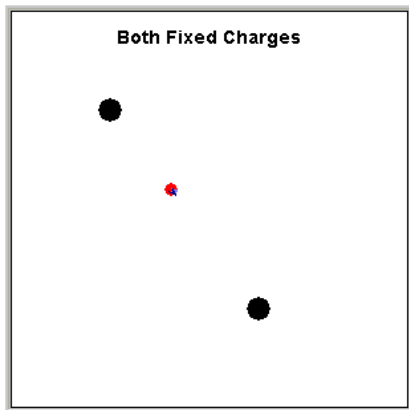
$F_{\text{red, first}} =$ _____, direction = _____

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).

3. Note that at (1.24 m, 2.34 m), the net force is zero, but that the charge due to each individual charge is non-zero. Explain.

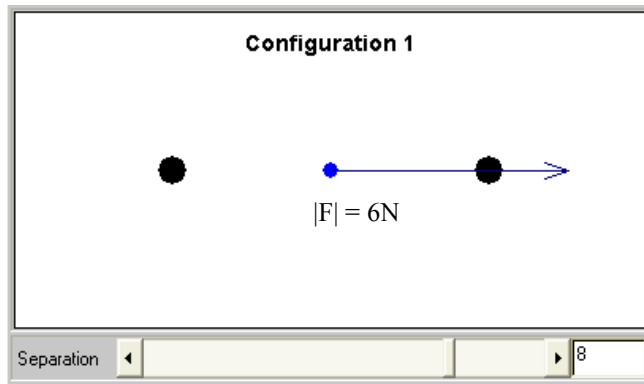


4. From the forces due to each individual charge, what is the ratio of the charges? (First charge is lower right)

To find the ratio 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 force due to each charge at that point (on the test charge)?

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

Part II: B. Equilibrium



In the image there are two black fixed charges and a blue 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 image shows the force on the test charge when it is at the midpoint between the two charges when they are separated by 8 m. The magnitude

of the force at this point is 6 N.

- There is a single point where the electric force on the test charge is zero. What is that point when the separation of the two fixed charges is 6 m.
- Do you have sufficient information to calculate the charge on the two black objects? If so, calculate the charge in coulombs.
- Find an expression for the position of zero force for any value of the charge separation.