Exercises

1. Charges A and B lie 5 cm apart, on a line. Charge A is $q_A = +2 \mu C$, and charge B is $q_B = -3 mC$. (Be careful of the metric prefixes!)
   (a) Before doing any calculation, determine the direction of the force on both charges. Which will feel the larger force, A or B?
   (b) Calculate the force (magnitude and direction) on both charges, using Coulomb’s Law.

2. Three charges are fixed on a line as shown. Find the force (magnitude and direction) on charge B.

3. Coulomb’s Law is

   $$\vec{F} = k \frac{q_1 q_2}{r^2} \hat{r}$$

   where $\hat{r}$ is the unit vector pointing from the source charge to the target charge (that is, from the forcer to the forcee). The unit vector is defined as the vector from charge to charge, divided by its length:

   $$\hat{r} = \frac{\vec{r}}{|\vec{r}|}$$

   so we can alternatively write Coulomb’s Law as

   $$\vec{F} = k \frac{q_1 q_2}{r^2} \frac{\vec{r}}{r} = k \frac{q_1 q_2}{r^3} \vec{r}$$

   This is more useful calculationally, but remember that the force decreases with the square of the distance, not the cube of the distance.

   Suppose a $+1 \mu C$ charge (charge A) sits at coordinate (1,3), and a $+3 \mu C$ charge (charge B) sits at coordinate (4,5). (The coordinates are in meters.)
   (a) Find the vector $\vec{r}$ from A to B.
   (b) Find the distance $|\vec{r}|$ (or $r$) from A to B.
   (c) Find the unit vector $\hat{r}$ from A to B.
   (d) Find the force on B due to A, in unit-vector notation.
   (e) Find the force on A due to B, in unit-vector notation.
4. In the figure, the four particles form a square of edge length \( a = 5.00 \text{ cm} \) and have charges \( q_1 = +10.0 \text{ nC}, q_2 = -20.0 \text{ nC}, q_3 = +20.0 \text{ nC}, \) and \( q_4 = -10.0 \text{ nC} \). In unit-vector notation, find the force on charge \( q_1 \).

Problems

5. Identical isolated conducting spheres 1 and 2 have equal charges \( Q \), and are separated by a distance which is large compared to their diameters (Fig. a). The electrostatic force acting on sphere 2 due to sphere 1 is \( \vec{F} \).

Suppose now that a third sphere 3, identical to the other 2 but initially neutral and attached to an insulating handle, is touched first (b) to sphere 1, then (c) to sphere 2, and then (d) finally removed. The electrostatic force on sphere 2 is now \( \vec{F}' \). Find the ratio \( \frac{|\vec{F}'|}{|\vec{F}|} \).

6. Consider the two fixed charges on an axis as shown. There is at least one point on the axis where one could place an electron and have it not feel a net force due to the other two charges. Find that point. (Note that you will have to consider three separate cases, depending on whether the electron is to the left of both charges, between them, or to the right of both.)