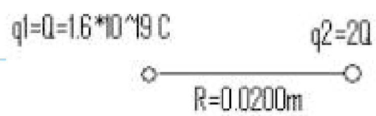
Note Title 9/2/2008

1

Two positively charged particles fixed in place on an x axis. The charge are q1=1.60*10^19 C and q2=3.2*10^19 C. The particles are separated by R=0.0200m. What are the magnitude and direction of the electrostatic force F12 on particle 1 from particle 2.

First let's build a diagram. This is a one dimensional problem with everything occuring on the x-axis. Please excuse my lack of artistic ability.



Now recall that the Coulomb force between two charges (q and Q) is given by the following equation. Also remember the sign convention... like charges ("positive" force) repel and opposite charges ("negative" force) attract.

$$F = \frac{kqQ}{r^2} = \frac{qQ}{4\pi\varepsilon_0 r^2}$$

Now input our variables and solve.

$$F = \frac{2QQ}{4\pi\varepsilon_0 R^2}$$

$$= \frac{2(1.6*10^{19}\,C)^2}{4\pi(8.85419*10^{-12}\,\frac{C^2}{Nm^2})(0.0200\,m)^2}$$

$$= 1.15*10^{52}\,N$$

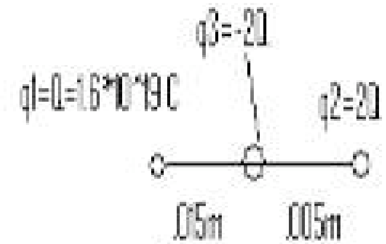
As we said earlier, a positive result means the charges are alike and therefore that the force is repulsive. So we say that charge 1 moves away from charge 2, or that charge 1 moves to the left. The magnitude is 1.15 * 10^52 N

2a

In the problem above, a particle c with a charge q3 = -3.20 * 10^19 C lies on the a axis particle 1 and 2. It is 0.75R from particle 1. What is the electrostatic force F on particle 1 to due particle 1 and 2?

This problem was a bit ambiguous. Nonetheless, everyone seemed to agree that Charge C should be on the x axis, and that the question was asking for the net force on particle 1. There was some disagreement on exactly where charge C should be placed. I will first show the problem as it would proceed under the interpretation that most students chose.

Once again we start with a diagram. We have placed the third charge between the first two. We can see that this configuration puts Q2 and Q3 in opposition with Q3 trying to pull Q1 to the right, and Q2 trying to push it to the left. This version also allows us to keep up our attractive/repulsive sign convention. As we will see, the other interpretation requires us to abandon that simplistic convention.



From the last problem we already know the formula for the Coulomb force, but now we want the net force which is given here. But this is just the sum of the forces on the charge. The math proceeds uneventfully. We end up with a negative result meaning that the force is attractive and that charge 1 accelerates to the right.

Be aware that we can not generally just use positive and negative and call them "repulsive" and "attractive" when talking about net forces. We are only able to do that in this example because both charges acting on particle one are on the same side of it. In the next example this convention will fail, as promised.

$$F = \frac{kqQ}{r^2} = \frac{qQ}{4\pi\varepsilon_0 r^2} F$$

$$F_{1net} = \sum_j F_{1j} = F_{12} + F_{13}$$

$$= \left(\frac{kqQ}{r^2}\right)_{12} + \left(\frac{kqQ}{r^2}\right)_{13} = \left(\frac{(2Q)Q}{4\pi\varepsilon_0 (R)^2}\right)_{12} + \left(\frac{(-2Q)Q}{4\pi\varepsilon_0 (.75R)^2}\right)_{13}$$

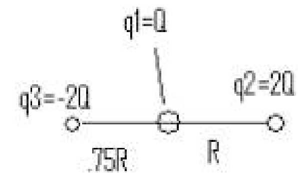
$$= \left(\frac{2(1.6*10^\wedge 19C)^2}{4\pi(8.854*10^{-12}\frac{C^2}{Nm^2})(.02m)^2}\right) + \left(\frac{-2(1.6*10^\wedge 19C)^2}{4\pi(8.854*10^{-12}\frac{C^2}{Nm^2})(.015m)^2}\right)$$

$$= \frac{2(1.6*10^\wedge 19C)^2}{4\pi(8.854*10^{-12}\frac{C^2}{Nm^2})}\left(\frac{1}{(.02m)^2} - \frac{1}{(.015m)^2}\right)$$

$$= -8.9*10^{51}N$$

2b

Now we concern ourselves with a problem where charges 2 and 3 are on opposite sides of charge 1, as depicted on the right. We can no longer just find the forces, positive for repulsive and negative for attractive, and just add them up, because Q2 repelling Q1 implies Q1 is being accelerated the opposite direction as when Q3 repels it. So we must now "convert" our direction to left/right before adding.



We will use the now familiar equation to find the Coulomb force acting between charges 1 and 2 and between charges 1 and 3, and we will use the sign convention of right being positive and left being negative. We will see that charge 2 is repelling charge 1, which means charge 1 is pushed to the left. Charge 3 attracts charge 1, so it gives charge 1 a pull to the left as well.

$$F_{12}=\left(\frac{(2Q)Q}{4\pi\varepsilon_0(R)^2}\right)_{12}=\left(\frac{2(1.6*10{\wedge}19\,C)^2}{4\pi(8.854*10^{-12}\frac{C^2}{Nm^2})(.02m)^2}\right)=1.15*10^{52}N=1.15*10^{52}N+2.04*10^{52}N(Left)$$

$$F_{13}=\left(\frac{(-2Q)Q}{4\pi\varepsilon_0(.75R)^2}\right)_{13}=\left(\frac{-2(1.6*10{\wedge}19\,C)^2}{4\pi(8.854*10^{-12}\frac{C^2}{Nm^2})(.015m)^2}\right)=-2.05*10^{52}N=2.05*10^{52}N(Left)$$

Now we simply add the forces in the usual way to get our final answer.

$$F_{1,net}=\sum_j F_{1j}=F_{12}+F_{13}$$
$$=-1.15*10^{52}N-2.05*10^{52}N=-3.20*10^{52}N$$
$$=3.20*10^{52}N(Left)$$