2/15 In Class – Coulomb's Law, and maybe E fields

This tutorial picks up where the last one left off. The first problem on this worksheet was number 6 on the last one. (2/14)

Quick summary of Coulomb's Law

Coulomb's Law gives the force between two point particles that have charges of q_1 and q_2. The separation between the two charges is r. The magnitude of the force is given by:

$$F = K\frac{q_1 q_2}{r^2}$$

and the direction of the force is along the line between the two particles and away for like charges and toward for opposite charges.

If there are more than two charges, you calculate the force for each pair that includes the one you're interested in, then add the pairs of forces. Remember that forces are vectors, so you have to worry about directions, and you may have to use components.

1. A point particle with a charge of $Q_1 = 1$ nC is at the origin. A second point particle with charge $Q_2 = -2$nC is at $x = 30$cm, and a third point particle with a charge of $Q_3 = 3$nc is at $x = 60$cm. Find the electric force on Q_3 due to the other two charges by the following steps:

   (a) Draw a picture of the configuration.

   (b) Draw a separate free body diagram of Q_3. Let's use Knight's convention that $\vec{F}_{13} = \vec{F}_{1on3}$ means the force of object 1 on object 3.

   (c) Use Coulomb's Law to evaluate the magnitudes of $\vec{F}_{13}$ and $\vec{F}_{23}$ You can leave this in symbols for now. (To make this all the same, we could use $d = 30cm$.)

   (d) Find the net force on Q_3. (Save this answer.)

2. A point particle with a charge of $Q_1 = 1$ nC is at the origin. A second point particle with charge $Q_2 = 2$nC is at $y = 30$cm, and a third point particle with a charge of $Q_3 = 3$nc is at $x = 60$cm. Find the electric force on Q_3 due to the other two charges by the following steps:

   (a) Draw a picture of the configuration.

(b) Draw a separate free body diagram of Q_3. Let's use Knight's convention that $\vec{F}_{13} = \vec{F}_{1on3}$ means the force of object 1 on object 3.

(c) Use Coulomb's Law to evaluate the magnitudes of $\vec{F}_{13}$ and $\vec{F}_{23}$ You can leave this in symbols for now.

(d) Find the net force on Q_3. You may leave your answer in components, as a column vector. (Save your answer.)

NEW: The electric field

Physicists were long unhappy with the notion of action-at-a-distance forces. Meaning, how do the two charges in the Coulomb Force affect each other if they don't touch? The answer: each charge generates a field everywhere in space.

The definition of the electric field, $\vec{E}$ is:

$$\vec{E} \equiv \frac{\vec{F}}{Q}$$

For point charges, this means that one point charge, q, generates a field of magnitude

$$E = K\frac{q}{r^2}$$

and you find the direction of the field at any point of interest by pretending to put a very small, positive test charge at that point and using Coulomb's Law to find the direction.

8. The electric field is a vector. It has no special name for its units. What is one way to write the units of $\vec{E}$?

9. Find the electric field a distance of 3m above a point particle with a +2C charge.

10. Find the electric field a distance of 3m below a point particle with a +2C charge.

11. Find the electric field a distance of 6m to the right of a point particle with a +2C charge.

12. Find the electric field a distance of 6m to the right of a point particle with a −2C charge.

13. A point particle with a charge of $Q_1 = 1$ nC is at the origin. A second point particle with charge $Q_2 = -2$nC is at $x = 30$cm,

(a) What is the electric field due to those two particles at $x = 60\text{cm}$? (Do this the "hard" way. Find $\vec{E}_1$ from $K\frac{q_1}{r^2}$; do the same for $\vec{E}_2$, then add the two vectors. Recall that you find the direction as if there were a positive test charge feeling the Coulomb force.)

(b) What force would a charge of 3nc feel at that same point ($x = 60\text{cm}$)? (Do this one the "easy" way. Multiply your $\vec{E}$ by Q. Do you understand why?) How does this compare to your answer to problem 1 (on todays worksheet = number 6 on yesterdays)?

14. A point particle with a charge of $Q_1 = 1$ nC is at the origin. A second point particle with charge $Q_2 = -2\text{nC}$ is at $y = 30\text{cm}$,

(a) What is the electric field due to those two particles at $x = 30\text{cm}$? (Do this the "hard" way. Find $\vec{E}_1$ from $K\frac{q_1}{r^2}$; do the same for $\vec{E}_2$, then add the two vectors. Recall that you find the direction as if there were a positive test charge feeling the Coulomb force.)

(b) What force would a charge of 3nc feel at that same point ($x = 60\text{cm}$)? (Do this one the "easy" way. Multiply your $\vec{E}$ by Q. Do you understand why?) How does this compare to your answer to problem 2 (on todays worksheet = number 7 on yesterdays)?