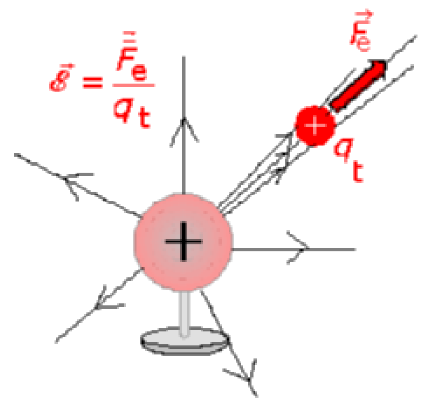
Section 15: Electric Field Strength

You can exert a force on things because you have strength. Since an electric field exerts a force on a charge that is in the field, the field must also have strength.

A charged spherical metal ball is placed on a glass insulating stand. All around it exists an electric field. When a small positive test charge, q, is brought into the vicinity of the charged sphere, the electric field, E, will exert a force, F, on the test charge.

The force exerted on the test charge will depend on the strength or intensity of the field at the point where the test charge is placed and on the size of the test charge.

$\boldsymbol{F \propto E}$ and $\boldsymbol{F \propto q}$



Electric Field Strength

Definition: The **<u>Electric field strength</u>** at a particular point in the field is defined as the force per unit charge on a positive test charge placed at that point, or in mathematical terms:

$$\boldsymbol{E = \frac{F_e}{q}}$$

where F_E is the electrical force in Newtons (N)

q is the positive test charge in Coulombs (C)

$\boldsymbol{E}$ is the electric field strength in Newtons/Coulomb (N/C)

The units of electric field strength are N/C. Unless it becomes critical that the direction be maintained in the computations, we will compute the magnitude $\boldsymbol{E}$ from $\boldsymbol{E = \frac{F_e}{q}}$, and add the appropriate direction to the final answer if required. In many textbooks the term **electric field strength** is shortened to **electric field**.

Examples

1. A charged rubber balloon has an electric field around it. At a point in the field, a test charge of 1.5 μC experiences a force of 3.0×10^{-4} N. What is the electric field strength?

2. A test charge of 1.3×10^{-7} N is placed in an electric field of 3.9×10^{3} N/C. What is the electric force exerted on the test charge?

3. What is the value of a test charge that experiences an electric force of 7.6×10^{-2} N in an electric field of 9.5×10^{3} N/C?

Note: the main charge (the one causing the field) did not enter into any calculations. This means that we don't have to worry about the main charge being a point charge, as was required by Coulomb's Law.

In other words, it is permissible to use E = F_e / q_t when the main charge is distributed over different shape surfaces--it doesn't have to be on a nice, neat, tiny sphere.

Another way to calculate Electric Field Strength

However, we are willing to restrict the main charge, qm, to a point source then we can derive another expression for $\boldsymbol{E}$.

Recall Coulomb's Law: $\boldsymbol{F} = \frac{kq_1q_2}{r^2}$

If the source charge, q_m, is a point charge, then the force experience by a test charge qt placed near the source charge, q_m, is given by: $\boldsymbol{F} = \frac{kq_mq_t}{r^2}$.

Substitute this expression into $\boldsymbol{E} = \frac{F}{q_t}$ and simplify.

TWO EXPRESSIONS FOR ELECTRIC FIELD STRENGTH

Use $\boldsymbol{E} = \frac{F_e}{q}$, when the main charge is unknown or not a point source.

Use $\boldsymbol{E} = \frac{kq_m}{r^2}$, when there is not test charge given and when both the main charge and the distance from the main charge are known. This reinforces the idea that the electric field strength even if there are not test charges around.

Examples:

1. Calculate the field strength 26.5 cm from a charge of -9.7 μC.

2. The electric field strength is 2.6×10^3 N/C at a point which is 68.4 cm from a charged object. What is the charge on the object?

3. At what distance from a charge of 6.2 μC is the electric field 4.2×10^2 N/C?

4. A) Charges A, and C are in a straight line a distance 30.0 cm apart. Find the net electric field strength at the point midway between the charges. The charges are as follows: A..................$^-$3.0 μC C..................$^-$5.0 μC

   B) If a +4μC is placed midway between the two charges, what electric force will it experience?

5. Two point charges q1 = 3.6×10^{-6} C and q2 = -2.7×10^{-6} C are arranged as shown:

Find the net electric field strength at point A due to the combined electric fields of both charges.

Homework:

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