PHYS 2212

Look over
Chapter 22 sections 1-8
Examples 2, 4, 5,

PHYS 1112

Look over
Chapter 16 sections 7-9
examples 6, 7, 8, 9

Things To Know

1) What is an Electric field.
2) How to calculate the electric field for a point charge.
3) What the electric field is between two charges.
4) How to find the electric field for Two or more point charges.
5) How to find the acceleration of a charged object in an electric field.

Action at a Distance

Some forces we can see how the forces is being applied.

Some forces produce an action over a distance of separation. To understand these forces we use the idea of a **Field**.

Fields

A **Field** is any physical quantity which can be specified simultaneously for all points within a given region of interest.

There are two types of fields:

❶ **A Scalar Field** - this type of field assigns a value to every point in space. Example: the temperature in a room.
❷ **A Vector Field** - this type of field assigns a vector to every point in space. Example: The gravitational field around the earth. $\vec{g} = G\frac{M_E}{r^2}$

The Electric Field

To define the **Electric Field** at some point we imagine placing a small test charge q_0 [taken to be (+)] at the point in space that is to examined, and we measure the electric force **F** that acts on this charge. The electric field at this point is then defined as:

$$\vec{E} = \lim_{q_0 \Rightarrow 0} \frac{\vec{F}}{q_0}$$

The direction of E is given by the direction in which the positive test charge would tend to move.

Lines of Forces

Michael Faraday, who introduced the idea of electric fields thought of space around a charged object as filled with **"lines of force"** or **Electric Field Lines**.

The relation between the field lines and the electric field vectors is this:

①At any point, the direction of a straight field line or the direction of a tangent to a curved field line gives the direction of **E** at that point.
②Where the field lines are close together, the magnitude of **E** is large, and where they are far apart, the magnitude of **E** is small.

The Electric Field Lines of a Sphere of Uniform Charge

Electric field lines extend away from positive charge and towards negative charge.

E of a Point Charge

To find the force on a test charge q_0 due to a (+) point charge q we can use Coulomb's law as:

$$\left|\vec{F}\right| = \frac{1}{4\pi\varepsilon_0}\frac{|q|\,|q_0|}{r^2}$$

The direction of F is away from q.

E of a Point Charge

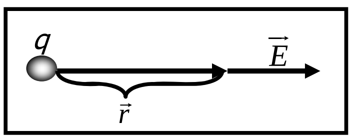
Then to find the electric field we can use:

$$\left|\vec{E}\right| = \lim_{q_0 \Rightarrow 0} \frac{\left|\vec{F}\right|}{q_0} = \frac{1}{4\pi\varepsilon_0}\frac{|q|}{r^2}$$

Where as we have seen **E** points away from q.

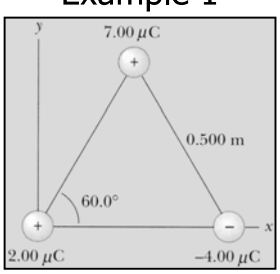
To find the electric field due to a collection of charges we can use the Superposition Principle.

E is also a Vector



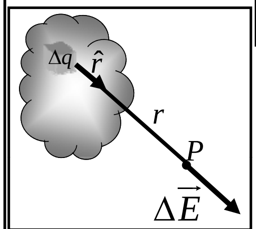
$$\vec{E} = k\frac{q}{r^3}\vec{r} = k\frac{q}{r^2}\hat{r}$$

Example 1



1)Three charges are at the corners of an equilateral triangle. What is the electric field at the position of the 2.00μC charge?
What is the force on the 2.00μC charge?

The Electric Filed of a Continuous Charge Distribution



The Electric field at Point P due to a piece of the object is given by:

$$\Delta E = k\frac{\Delta q}{r^2}\hat{r}$$

The total Electric field is given by the sum over all the pieces of the object:

$$\vec{E} = k\left(\lim_{\Delta q_i \to 0}\sum_i \frac{\Delta q_i}{r_i^2}\hat{r}\right)_i = k\left(\int \frac{dq}{r^2}\hat{r}\right)$$

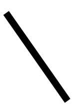
Charge Densities

If a charge Q is uniformly distributed throughout a volume V the Volume Charge Density:

$$\rho = \frac{Q}{V}$$

If a charge Q is uniformly distributed on a surface area A the Surface Charge Density:

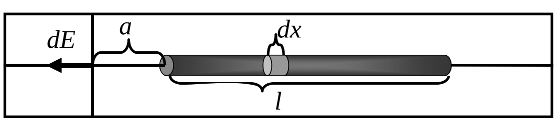
$$\sigma = \frac{Q}{A}$$



If a charge Q is distributed on a line of length l the Linear Charge Density:

$$\lambda = \frac{Q}{l}$$

Example 2



2)A rod of length l has a uniform positive charge distribution λ and a total charge Q. Calculate the electric field at a point which is a distance *a* from the end of the rod.

A point Charge in an Electric Field

If we want to describe the motion of a charged particle we need to know the acceleration of the particle.

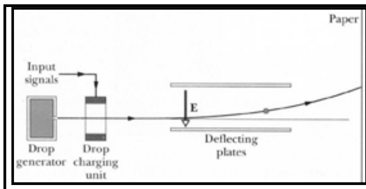
$$\vec{F} = \vec{E}q$$

And thus the acceleration is given by

$$\vec{a} = \frac{\vec{F}}{m} = \frac{\vec{E}q}{m}$$

If the particle has a mass m.

Example 3



3)An ink drop with a mass m of 1.3×10^{-10} kg and a negative charge of magnitude $q=1.5\times10^{-13}$ C enters the region between the plates, initially moving along the x-axis with speed v_x=18m/s. The length L of the plates is 1.6 cm. The plates are charged and thus produce an electric field of magnitude 1.4×10^{6} N/C. What is the vertical deflection of the drop at the far edge of the plates?