PHYS 2212

Read over Chapter 23 sections 1-9
Examples 1, 2, 3, 6

PHYS 1112

Look over
Chapter 16 Section 10
Examples 11, 12,

Good Things To Know

1) What a Gaussian surface is.
2) How to calculate the Electric field Flux for an object in an electric field.
3) How to find the electric field for symmetrical objects using Gaussian

Law

There is another formulation of Coulomb's law derived by a German mathematician and physicist **Carl Friedrich Gauss**. This law called **Gauss' Law**, can be used to take advantage of special symmetry situations.

Gaussian Surface

Central to Gauss' law is a hypothetical closed surface called a **Gaussian Surface**.

The Gaussian surface must always be a closed surface, so a clear distinction can be made between points that are inside the surface, on the surface, and outside the surface.

Gaussian Surface

If you have established a Gaussian surface around a distribution of charges then Gauss' law comes into play.

"Gauss" law relates the electric field at points on a (closed) Gaussian surface to the net charge enclosed by that surface"

Flux

Suppose you aim an airstream of velocity *v* at a small square loop of area *A*

If we let Φ represent the **Flux** or volume flow rate (volume per unit time) at which air flows through the loop. This rate will depend upon 3 things:

❶The size of the loop.
❷The velocity of the air flow.
❸The angle between the air flow velocity and the surface of the loop. If $\theta=90°$ then $\Phi=0$. If $\theta=0°$ then Φ is at its max.

Air flux

So we can write the Flux as:

$$\Phi = vA\cos\theta = \vec{v} \bullet \vec{A}$$

Where A is a vector that is perpendicular to the loop and has the magnitude equal to the area of the loop.

In a more abstract way we can assign a velocity vector to each point in the airstream passing through the loop. These velocity vectors compose a vector field. So we can define the **Flux** as a flux of a vector field through the loop.

Flux of an Electric Field

The flux of an electric field across a Gaussian surface is defined as:

$$\Phi \cong \sum_i \vec{E}_i \bullet \Delta\vec{A}_i$$

Flux

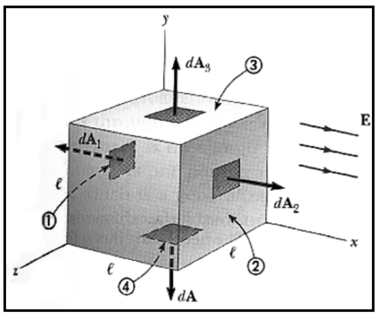
The exact definition of the flux of the electric field through a closed surface is found by allowing the area of the squares to become infinitely small.

In terms of integration:

$$\Phi = \oint \vec{E} \bullet d\vec{A}$$

The electric flux Φ through a Gaussian surface is proportional to the net number of electric field lines passing through that surface.

Example 1



1)What is the flux through a cube of side l due to an Electric field in the +x direction.

Gauss' Law

If we have a Gaussian surface that surrounds no charge, then no electric field lines can originate from or end inside that closed surface.

So the same number of field lines that enter must exit the surface so the flux must be zero. Thus:

"If there is no charge inside a closed surface, the electric flux through the surface is **zero**."

An Example From Fishing

Suppose that our Gaussian surface is formed by a fish net, and that net is placed in a river.

Gauss' Law Near Charges

When the Gaussian surface encloses a net charge, the electric flux through the surface is not zero, and Gauss' Law expresses the flux in terms of the charge enclosed.

Lets look at the flux due to a point charge.

$\Phi = \frac{q}{\varepsilon_0}$ For a point charge q

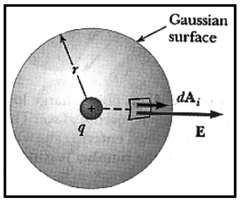
In general: $\varepsilon_0 \Phi = q_{enc}$

Where q_{enc} is the net charge enclosed and is the algebraic sum of all the enclosed positive and negative charge.

A Charged Isolated Conductor

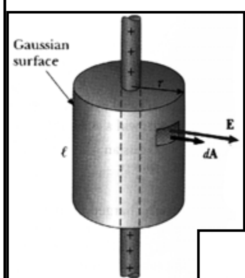
If an excess of charge is placed on an isolated conductor, that amount of charge will move entirely to the surface of the conductor. None of the excess charge will be found within the body of the conductor.

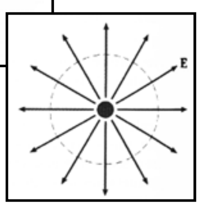
Example 2



2)What is the Electric field due to a point charge?

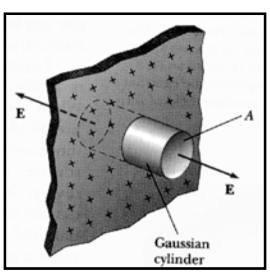
Example 3





3) What is the electric field due to a infinitely long charged, cylindrical plastic rod with a uniform linear charge density (charge per unit length) of λ.

Example 4



4)What is the electric field due to a thin infinite insulating sheet with a uniform surface charge density (charge per unit area) σ.