Electric Flux

Electric flux, Φ, of the electric field, E, through the surface, A, as:

$$\Phi = E \cdot A = EA\cos\theta$$

If the surface is curved, then we can

1. Divide the surface into small regions with area dA.
2. $d\Phi = E \cdot dA$
3. Obtain the total flux by integrating over the surface A, $\Phi = \int E \cdot dA$

Electric Field in a Sphere

If there is a positive point charge q, through a spehere of radius R centered at the charge, the electric field is $E = \frac{kq}{r^2}$ at any distance $r >= R$.

In a solid sphere of radius R with the uniformly distributed charge Q, find $E(r)$ at a point inside the sphere by:

- $Q_{enc} = \frac{r^3}{R^3}Q$
- So for $r < R$, $E(r) = \frac{kQ \times r^3/R^3}{r^2} = \frac{kQr}{R^3}$

Gauss's Law

Electric flux through any closed surface always equals:

$$\int E \cdot dA = \frac{Q_{enc}}{\epsilon_0}$$

where Q_{enc} is the enclosed charge

Electric Flux of Multiple Charges

In the case of multiple charges through any closed surface:

- The contribution to the total flux for any charge q_i inside the surface is q_i/ϵ_0.
- The contribution to the total flux for any charge outside the surface is zero.
- $\Phi = Q_{in}/\epsilon_0$ where Q_{in} is the sum of the charges inside the surface