



ELECTROMAGNETIC FIELDS AND WAVES



Field Due to Continuous Volume Charge Distribution



In electrostatics, when charge is continuously distributed over a **volume**, the electric field at a point is found by integrating over the entire charge distribution.

Instead of discrete charges, we consider **volume charge density** (ρ_v)





Volume Charge Density (ρ_v)

The charge per unit volume at a given point in space.

$$ho_v = rac{dq}{dV}$$

where:

- ρ_v → Volume charge density (C/m³)
- dq → Small charge element (C)
- dV → Small volume element (m³)



Expression for Electric Field



From **Coulomb's Law**, the differential electric field due to an infinitesimal charge element dq is:

$$d{f E}=rac{1}{4\piarepsilon_0}rac{dq}{r^2}\hat{r}$$

Since dq is distributed over a volume, we replace it with $\rho_v dV$:

$$d{f E}=rac{1}{4\piarepsilon_0}rac{
ho_v dV}{r^2}\hat{r}$$

To find the total electric field at a point, integrate over the entire charge distribution:

$$\mathbf{E} = rac{1}{4\piarepsilon_0}\int_Vrac{
ho_v dV}{r^2}\hat{r}$$

V is the volume containing the charge distribution.

 \hat{r} is the unit vector from the charge element to the point of interest. r is the distance between the charge element and the field point.



Electric Field Due to a Uniformly Charged Sphere

For a sphere of radius R with uniform charge density ρ_v , total charge is:

$$Q=\int_V
ho_v dV =
ho_v rac{4}{3}\pi R^3$$

Using Gauss's Law, the electric field is:

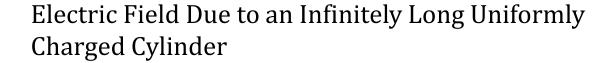
Inside the sphere (r < R):

$$E=rac{1}{4\piarepsilon_0}rac{
ho_v4\pi r^3/3}{r^2} \ E=rac{
ho_v}{3arepsilon_0}r$$

Outside the sphere (r > R):

$$E = rac{1}{4\piarepsilon_0}rac{Q}{r^2}$$







Using Gauss's Law, for a cylinder of radius R with uniform charge density ρ_v :

• Inside the cylinder (r < R):

$$E=rac{
ho_v r}{2arepsilon_0}$$

• Outside the cylinder (r > R):

$$E=rac{\lambda}{2\piarepsilon_0 r}$$

where $\lambda = \rho_v \pi R^2$ is the linear charge density.





Thank you

