Electric field

Electric Field

The **electric field** is a vector field that represents the force per unit charge exerted on a positive test charge placed in the field. It is a fundamental concept in electromagnetism and is used to describe the influence of electric charges on their surroundings.

Definition: The electric field $\vec{E}$ at a point in space is defined as the force $\vec{F}$ experienced by a small positive test charge q placed at that point, divided by the magnitude of the charge:

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

Units: The SI unit of the electric field is **Newtons per Coulomb (N/C)** or **Volts per meter (V/m)**.

Direction: The direction of the electric field is the direction of the force that would act on a positive test charge.

Electric Field Lines

Electric field lines are a visual representation of the electric field. They are imaginary lines drawn in such a way that:

. **Direction**: The tangent to an electric field line at any point gives the direction of the electric field at that point.

. **Density**: The density of the lines (number of lines per unit area) is proportional to the magnitude of the electric field. A stronger field is represented by closer lines, while a weaker field is represented by spaced-out lines.

. **Start and End**: Electric field lines start from **positive charges** and end at **negative charges**. If there is an excess of one type of charge, some lines may start or end at infinity.

. **No Intersection**: Electric field lines never cross each other. If they did, it would imply two different directions for the electric field at the same point, which is impossible.

Properties of Electric Field Lines

. **Direction**: The direction of the electric field at any point is tangent to the field line at that point.

. **Strength**: The strength of the electric field is proportional to the density of the field lines. Closer lines indicate a stronger field.

. **Continuous**: Electric field lines are continuous and do not break in a charge-free region.

. **Perpendicular to Conductors**: Near the surface of a conductor, electric field lines are perpendicular to the surface. This is because the electric field inside a conductor in electrostatic equilibrium is zero, and any excess charge resides on the surface.

. **No Closed Loops**: Electric field lines do not form closed loops in electrostatics. They start at positive charges and end at negative charges.

. **Symmetry**: In systems with symmetrical charge distributions (e.g., a point charge, infinite plane, or charged sphere), the electric field lines exhibit symmetry.

Key Points to Remember

Electric field lines provide a qualitative way to visualize the electric field.

The electric field is a vector quantity, while electric field lines are a graphical tool.

The concept of electric field lines is particularly useful for understanding the behavior of charges in electric fields and for solving problems in electrostatics.