Electric Field Lines

Electric field lines are continuous lines which have the same direction as the electric field

- Electric field lines are continuous curves tangent to the electric field vectors
- Closely spaced field lines indicate a greater field strength
- Electric field lines start on positive charges and end on negative charges
- Electric field lines never cross

$$\vec{E}(\vec{r}) = \int \frac{kdq}{r^2}\hat{r}$$

where dq is a small element of charge at each point in a electric field produced by a continuous distribution of charge and r is the distance from that small point in the electric field to the point

Linear Charge Density

- The linear charge density of an object of length L and charge Q is defined as $\lambda = \frac{Q}{L}$
- Linear charge density, which has units of C/m, is the amount of charge per meter of length

$$E = \frac{\lambda}{2\pi\epsilon_0 r}$$

Surface Charge Density

- The surface charge density of a two-dimensional distribution of charge across a surface of area A is defined as $\eta = \frac{Q}{A}$
- Surface charge density, which has units of C/m^2, is the amount of charge per square meter

Electric Dipoles

Dipole moment $p = q \times d$ where d is a vector directed from negative charge to the positive one and q is the magnitude of charge

$$E = \frac{2kp}{r^3}$$

where $\epsilon_0 = 8.854 \times 10^-12 \, C^2/N \cdot m^2$ is the vacuum permittivity

When the dipole moment $\vec{p}$ is at an angle θ to the field, causing the dipole to experience a torque, $\tau = r \times F$. Each charge experiences force $F = qE$. The net force on the dipole is zero because the forces are of opposite directions so dipole will not move as a whole in electric field.

$$|\tau| = pE\sin(\theta)$$

where θ is the angle between the dipole moment and the electric field

Capacitors

$$E = \frac{V}{D}$$

Where:

- E is the elctric field strength
- V is the potential difference across the plates
- d is the distance between the plates

Key Points

- The electric field inside an ideal parallel plate capacitor is uniform and directed from the postiively charged plate to the negatively charged plate
- If you know the surface charge density $\sigma = \frac{Q}{A}$ on the plates, the electric field can also be calculated using: $E = \frac{\sigma}{\epsilon_0}$