13 Electric Fields

Force between point charges

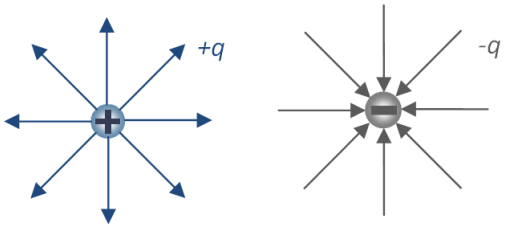
Coulomb's Law states that the force F between two point charges Q_1 and Q_2 separated by a distance r in free space is given by $F = \frac{Q_1 Q_2}{4\pi\varepsilon_0 r^2}$ where ε_0 (given) is the permittivity of free space.

Concept of an Electric Field

An **electric field** is a region of space where an electric charge experiences an electric force.

Electric Field Lines

Electric field lines indicate direction of force experienced by a positive charge at a particular position. Its density indicates field strength.
- Electric field lines can never cross each other's path
- Electric field lines originate from the surface of a conductor perpendicularly
- In a conductor, there are no field lines as the electric field is zero



Electric field lines due to point charges

Electric field strength *E* at a point is defined as the force per unit positive charge acting on a small test charge at a point. [unit: N C^{-1}]

$$F = qE$$

Electric Field of a Point Charge

The field strength at a distance r from a point charge Q in free space is $E = \frac{Q}{4\pi\varepsilon_0 r^2}$

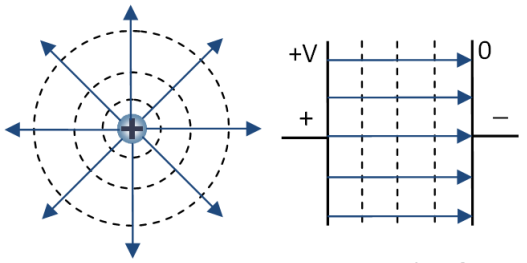
Electric Potential

The **electric potential *V*** at a point is defined as the work done in bringing a unit positive charge from infinity to a point. The SI unit of electric potential is the **volt** (V). At infinity, the potential is zero.
The relationship between electric field and electric potential is given by $E = -\frac{dV}{dr}$.
The potential at a distance r from a point charge Q is $V = \frac{Q}{4\pi\varepsilon_0 r}$ (given).

The **electric potential energy *U*** of an electric charge q at a point is $U = qV$. When moving between 2 points, the change in U is $\Delta U = q\Delta V$.

Equipotential Surface

An equipotential surface is where all points on the surface have the same potential, and is always perpendicular to electric lines of force, which point from high to low potential.



Equipotential surfaces around point charge

Equipotential surfaces between parallel plates

Electric field lines

Equipotential lines

Uniform electric field

A **uniform** electric field E is produced between two uniformly charged parallel plates, given by $E = \frac{\Delta V}{d}$ where ΔV is the p.d. between plates and d is the plate separation. A charge q between the plates will feel a constant electric force $F = qE$.
Relationship between F and U: $F = -\frac{dU}{dr}$