Electric Fields

Electric Field and Field Strength

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

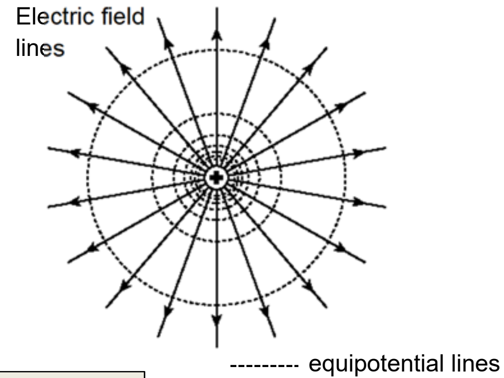
Electric Field Strength, *E*

The electric field strength E at a point is the electric force per unit positive charge acting on a small stationary charge placed at that point.

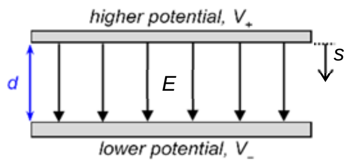
$$E = \frac{F}{q}$$

Electric Field Lines

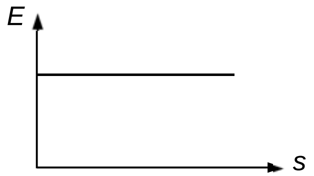
- go from high to low potential (start on a positive charge, end on a negative charge)
- are perpendicular to surface of charge conductor
- are smooth curves or lines that never touch or intersect
- closer lines indicate a strong electric field
- the tangent to the field lines at a point indicates the direction of the electric field vector at that point.

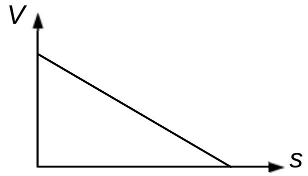


Uniform Electric Field



- field strength, $E = \frac{\Delta V}{d}$ is the same at all points
- potential, V decreases linearly along the field
- variation of E and V with distance s from the plate with higher potential:





- $a = \frac{F_{net}}{m} = \frac{F_E}{m} = \frac{qE}{m} = \frac{q\Delta V}{md}$
- charged particles with velocity component at right angles to the field will follow a **parabolic path**
- apply **Kinematics** (projectile motion) or/and **Conservation of Energy** (total $E_K + U_E$ = constant, where $U_E = Vq$)

Relationship between *E* and

The electric field strength at a point is numerically equal to the potential gradient at that point.

$$E = -\frac{dV}{dr}$$

direction of the electric field points from high potential to low

Electric Potential, *V*

- The electric potential at a point in an electric field is defined as the work done per unit positive charge by an external agent in bringing a small test charge from infinity to that point without a change in the kinetic energy of the charge.
- $V = 0$ at infinity

Point Charges

Electric Field Strength, *E* (vector)

Unit: N C^{-1} or V m^{-1}

$$E = \frac{Q}{4\pi\varepsilon_0 r^2}$$ substitute Q without signs

E points away from positive charge, towards negative charge

$$E = -\frac{dV}{dr}$$

Electric Potential, *V* (scalar)

Unit: V

$$V = \frac{Q}{4\pi\varepsilon_0 r}$$ **substitute signs of Q**

$F = Eq$

$U = Vq$

Electric Force, F_E (vector)

Unit: N

$$F = \frac{Qq}{4\pi\varepsilon_0 r^2}$$ substitute Q,*q* without signs

Unlike charges attract. Like charges repel.

Coulomb's law: The magnitude of the force between two point charges is directly proportional to the product of the charges and inversely proportional to the square of the distance between

$$F_E = -\frac{dU}{dr}$$

Electric Potential Energy, U_E (scalar)

Unit: J

$$U = \frac{Qq}{4\pi\varepsilon_0 r}$$ **substitute signs of Q and *q***