Electrostatic Potential

Electrostatic Potential

Work done per unit positive test charge by an external force in beinging a unit positive charge from infinity to a point in the presence of another point charge.

$$V = \frac{W}{q_0} = \frac{q}{4\pi\varepsilon_0 r}$$

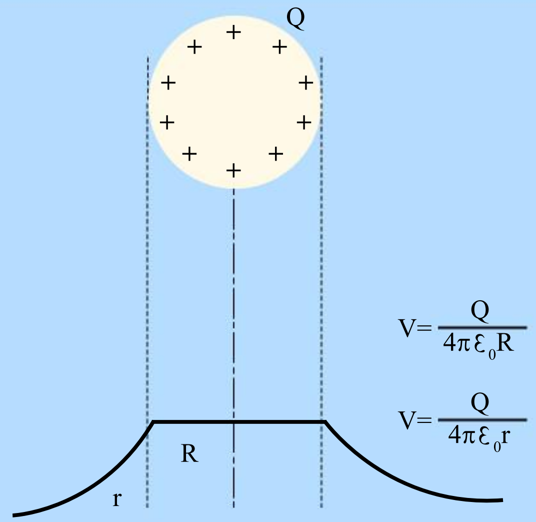
Potential Energy

For a system of two charges

$$U = \frac{q_1 q_2}{4\pi\varepsilon_0 r_{12}}$$

Electric Potential due to a Uniformly Charged Spherical Shell

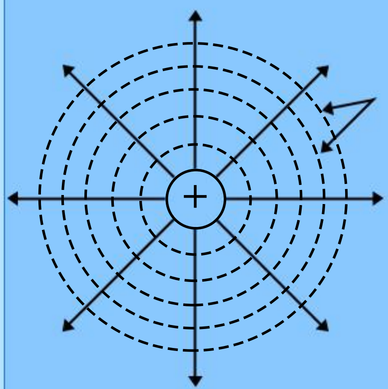
Outside the shell	Inside the shell
$V = \frac{1}{4\pi\varepsilon_0 r}\frac{q}{r}$; r>R	$V = \frac{1}{4\pi\varepsilon_0 r}\frac{q}{R}$

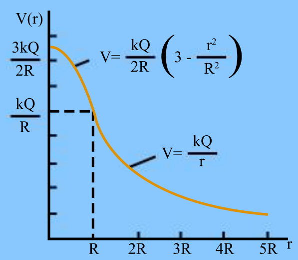


Equipotential Surface

Surface having same electrostatic potential at every point.

- Do not intersects each other
- At every point $\vec{E} \perp$ surface
- Work done in moving a charge is zero $W_{net} = 0$

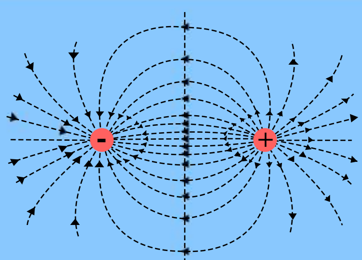




Electric Potential due to a Non-conducting solid Sphere

Outside the sphere	on the sphere i.e.,	inside the sphere
$V = \frac{1}{4\pi\varepsilon_0 r}\frac{q}{r}$; r >R	$V = \frac{1}{4\pi\varepsilon_0}\frac{q}{R}$;r =R	$V = \frac{1}{4\pi\varepsilon_0}\frac{q(3R^2-r^2)}{2R^3}$;r <R

Electric Potential due to an Electric Dipole



At any arbitrary point; $v = \frac{p\cos\theta}{4\pi\varepsilon_0 r^2}$

At axial point $v = \frac{p}{4\pi\varepsilon_0 r^2}$

At equatorial v = 0

Potential energy of a dipole in external field

$U(0) = pE(\cos\theta_0 - \cos\theta)$

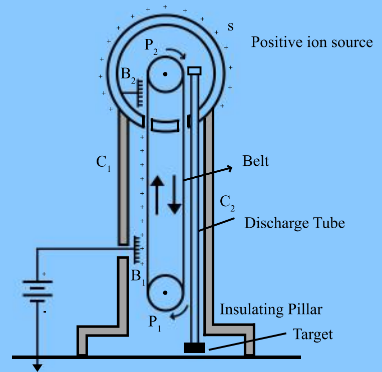
$\rightarrow$ when intially at $\theta_0 = 90^0$

$$\Rightarrow U = -\vec{p}\cdot\vec{E}$$

Van de Graff Generator

Principle

- If an electric charge is imparted to the inside of a spherical conductor, it is distributed entirely on its outer surface.
- Pointed ends cannot retain charge due to high charge density on them.



Electric Field Between Plates

Charge on the inside of each plate: +Q on the top, - Q on the bottom

Capacitor and Capacitance

Capacitor is used to store electrical energy. Capacitance is defined energy. Capacitance is defined as the ratio of the charge stored to the potential between the plates.

$$C = \frac{Q}{V}$$

Types of Capacitors

Air filled parallel plate capacitor

$$C = \frac{\varepsilon_0 A}{d}$$

Spherical capacitor

$$C = 4\pi\varepsilon_0 \frac{ab}{b-a}$$

Relation Between Field and Potential

$$\vec{E} = -\vec{\nabla}V \qquad E = -\frac{dV}{dr}$$

Energy stored in a Capacitor

$$U = \frac{1}{2}CV^2 = \frac{1}{2}QV = \frac{1}{2}\frac{Q^2}{C}$$