ELECTROSTATIC POTENTIAL AND CAPACITANCE

ELECTROSTATICS OF CONDUCTORS

CONDUCTOR

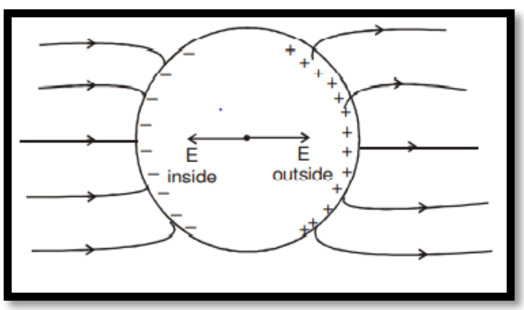
Type of materials

1. conductors (All electrons are free)
2. Semi-conductors (Some electrons are free)
3. Insulators (all electrons are bounded)

Conductors:

A conductor contains free electrons, which can move freely in the material, but cannot leave it.

On applying an external electric field on conductor charges of a conductor adjust themselves in such a fashion that the net electric field inside the conductor is zero under electrostatics conditions.



Net $\vec{E} = 0 \Rightarrow$ Potential is constant

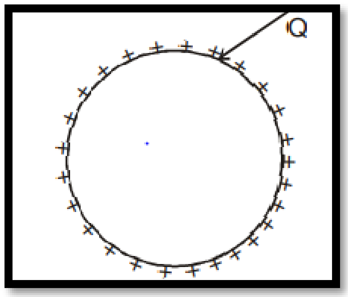
∴ **Conductor behaves as an equipotential surface**

Being an equipotential surface, electric field lines will terminate or originate perpendicularly Let us now consider the interior of a charged conducting object. Since it is a conductor, the electric field in the interior is everywhere zero. Let we analyses a Gaussian surface inside the conductor as

close as possible to the surface of the conductor. Since the electric intensity E is zero everywhere inside the conductor, it must be zero for every point of the Gaussian surface. Hence the flux through the surface.

$\oint \vec{E}.d\vec{S}$ will be zero. Therefore, according to Gauss's law $\oint \vec{E}.d\vec{S} = \frac{q}{\varepsilon_0}$ the net charge inside the Gaussian surface and hence inside the conductor must be zero. Since there can be no charge in the interior of the conductor charge given to the conductor will reside on the surface of the conductor.

All the charge given to the conductor reside on the surface of the conductor



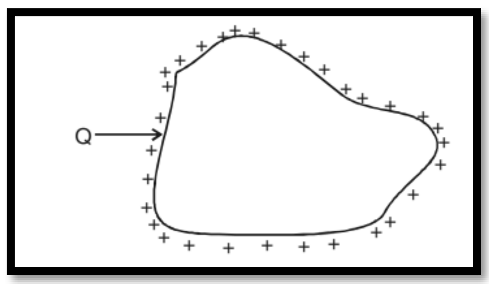
Till now we have only discussed the case of uniform shaped bodies on which the charge distribute itself uniformly.

But what about the charge distribution on irregular shaped bodies? Does in this case also uniform charge distribution take place? .... **NO**

In this case $\sigma \alpha \frac{1}{r_c}$

σ → charge per unit area

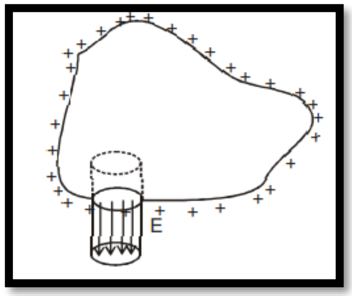
r_c → radius of curvature



Let us consider a random shaped body and find Electric field due to a small portion of this body. However, the σ is not uniform everywhere but for a small area dA, we can assume that σ is constant. Considering a cylindrical gaussian surface, we will calculate flux pasing through the cross section dA.

$$\phi_{net} = \oint \vec{E}.d\vec{S} = \frac{q_{in}}{\varepsilon_0}$$

$\varphi_{net} = \varphi_{curved\ surface} + \varphi_{outer\ flat\ surface} + \varphi_{inner\ flat\ surface}$ $\varphi_{curved\ surface} = 0$



because no flux is passing through lateral surface (electric field lines are perpendicular to area vector.)

$$\vec{E}.d\vec{S} = 0$$

$$\varphi_{\text{inner flat surface}} = 0$$

because $\vec{E}$ inside conductor = 0

$$\frac{q_{in}}{\varepsilon_0} = \varphi_{\text{outer flat surface}}$$

$$\frac{\sigma dA}{\varepsilon_0} = \vec{E}.d\vec{S}$$

$$\Rightarrow \vec{E} = \frac{\sigma}{\varepsilon_0}$$