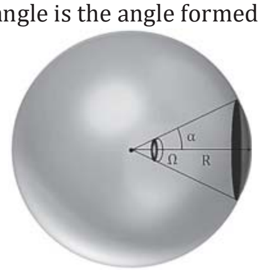
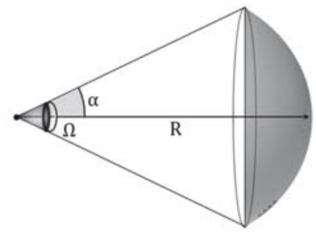
CALCULATION OF ELECTRIC FLUX USING SOLID ANGLE

Relation Between Plane Angle And Solid Angle

A plane angle is the angle formed by an arc (a segment of a circle) at a point.

A solid angle is the angle formed by an area (a portion of a sphere) at a point.





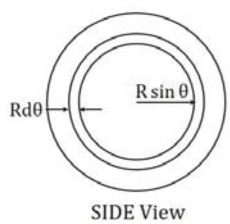
$\alpha = \frac{\text{Arc length}}{R}$ $\qquad \Omega = \frac{\text{Area of cap}}{R^2}$

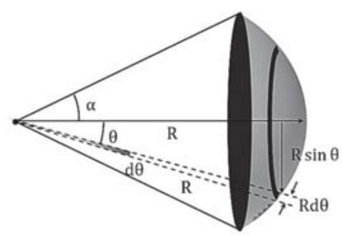
$\Omega = \frac{\text{Area of cap}}{R^2}$

Area of cup $= \int dA$

$$= 2\pi R^2 \int_0^{\alpha} \sin\theta d\theta$$
$$= 2\pi R^2[-\cos\theta]_0^{\alpha}$$
$$= 2\pi R^2(1-\cos\alpha)$$
$$\Omega = \frac{2\pi R^2(1-\cos\alpha)}{R^2}$$
$$\Omega = 2\pi(1-\cos\alpha)$$

Where, $\Omega =$ Solid angle, $\alpha =$ Plane angle

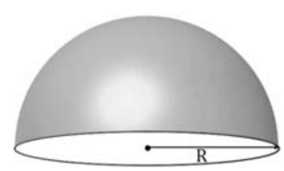




Ex. Find out the solid angle subtended by a hemisphere at its centre.

Sol.

$$\Omega = 2\pi(1-\cos\alpha)$$
$$= 2\pi\left(1-\frac{\cos\pi}{2}\right)$$
$$\Omega = 2\pi$$
$$\Omega = \frac{\text{Area of cap}}{R^2} = \frac{2\pi R^2}{R^2} = 2\pi$$
$$\Omega = 2\pi sr$$

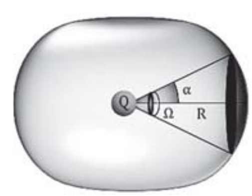


Electric Flux Through A Surface

The solid angle formed by any closed surface at an interior point $= 4\pi$

The electric flux produced by a charge Q passing through any closed surface $= \frac{Q}{2\varepsilon_0}$

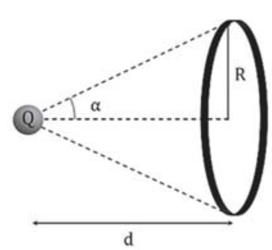
$$\phi = \frac{Q}{2\varepsilon_0}(1-\cos\alpha)$$



Ex. A charge Q is placed at a distance *d* from a disk of radius *R* as shown. Find out the electric flux passing through the disc.

Sol. We have, $\phi = \frac{Q}{2\varepsilon_0}(1-\cos\alpha)$

$$\phi = \frac{\theta}{2\varepsilon_0}(1-\cos\alpha)$$
$$= \frac{\theta}{2\varepsilon_0}\left(1-\frac{d}{\sqrt{d^2+R^2}}\right)$$
$$\phi = \frac{Q}{2\varepsilon_0}\left(1-\frac{d}{\sqrt{d^2+R^2}}\right)$$



Classification of material

Classification of material

- Conductor
  All the e^- (in conduction band) are free
- Semi- Conductor
  Some e^- are free and some are bounded
- Insulator
  All the e^- are bounded

Classification of material

Conductors

The electrical conductivity of a substance relies on the presence of free electrons within it. When there is a high abundance of free electrons, resulting in a free electron cloud, the material exhibits high conductivity. These materials are referred to as conductors.

Ex. Copper and silver

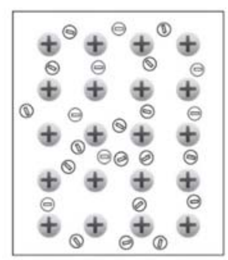
Insulator

If there is a low abundance of free electrons or no free electrons present within the material, the conductivity of the material will be significantly reduced, leading to its classification as an insulator.

Ex. Wood and rubber

Semi-Conductors

When a material's conductivity falls between that of a conductor and an insulator, it is categorized as a semiconductor.



Neutral conductor

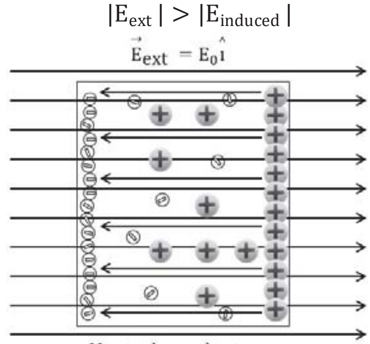
Properties Of Conductors

All the e^- (present in the conduction band) are free to move within the boundary of the surface.

All the e^- (within the conduction band) have the freedom to move within the boundary of the surface.

Inside conductor, $\vec{E}_{net} = \vec{E}_{ext} + \vec{E}_{induced}$

$$|\vec{E}_{ext}| > |\vec{E}_{induced}|$$



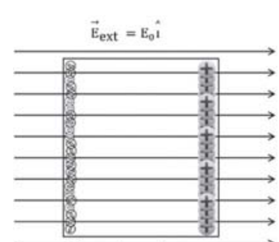
Neutral conductor

Under electrostatic equilibrium, net electric field ($\vec{E}_{net}$) inside a conductor is zero.

Inside conductor, $\vec{E}_{net} = 0$

At equilibrium, $|\vec{E}_{ext}| = |\vec{E}_{induced}|$

$$\vec{E}_{net} = 0$$



Neutral conductor

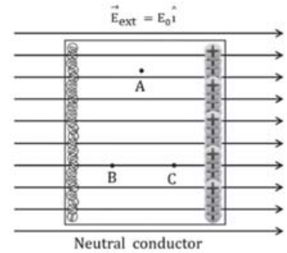
Conducting materials act as an equipotential region in an external electric field.

$$\text{If } E = 0 \Rightarrow V = \text{ Constat}$$

$$V_A = V_B = V_C = \text{ Constal}$$

We can say this conductor is equipotential region.

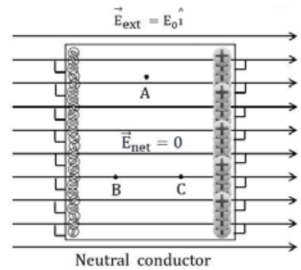
$$V_A = V_B = V_C$$



Electric field lines originate and terminate perpendicular from the surface of conductor.

lines terminate or original $\perp$ cularly from Conductor

$$V_A = V_B = V_C$$

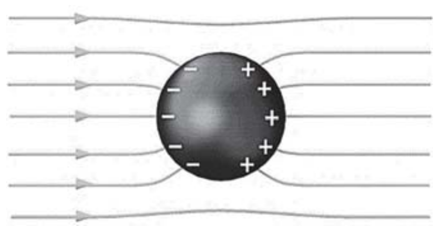


Electric field lines originate and terminate perpendicular from the surface of conductor.

Inside conductor,

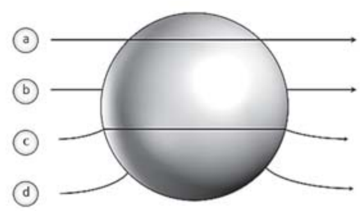
$$\vec{E}_{net} = 0$$

$$V = \text{ Constant}$$



Ex. A conductor is placed in an external electric field $\vec{E}_{ext} = E\hat{\imath}$ as shown. Which of the following representation of electric field lines around the conductor is correct?

Sol. Only in case (d) the field line enters and exits the conductor perpendicular to its surface. Thus, option (d) is the correct answer.



Repulsion is true test of electrification.