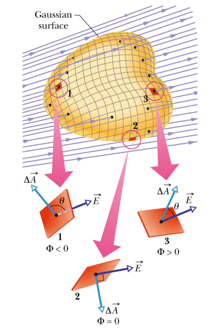
Gauss Law

22/11/2023 7:51 AM

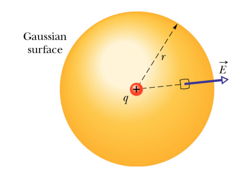


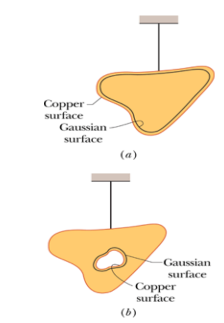
FLUX :- • The amount of field, material or other physical entity passing through a surface.
• The surface area can be represented as vector defined normal to the surface it is describing
• $\phi = \int \vec{E} \cdot \vec{dA}$

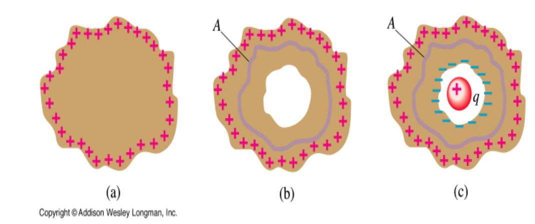
FLUX OF AN ELECTRIC FIELD :- • $\phi_E = EA$ OR $EA\cos\theta$ } when $\theta < 90°$ (out of surface) $\longrightarrow$ flux +ve; when $\theta > 90°$ (into surface) $\longrightarrow$ flux -ve where θ is angle b/w e-f vector & normal
• when we have a complicated surface, we can divide it into tiny elemental areas
• E flux is maximum when electric field lines are $\perp$ to the surface, and zero when parallel to the surface

GAUSS'S LAW :- • The total electric flux through a Gaussian surface is equal to the net charge enclosed divided by the permitivity of free space (ε_0).
• $\phi_{net} = \frac{q_{enc}}{\varepsilon_0}$
• The net charge q_{enc} is the algebraic sum of all the enclosed charges. net charge is always zero if no charge present.
• Charge outside the surface, no matter how large or how close it may be, is not included in the term q_{enc}.

DERIVATION OF GAUSS'S LAW USING COULOMB'S LAW :- • consider sphere drawn around positive charge
• $\phi = EA\cos\theta$ (θ alway 90° through sphere)
• for a point charge $E = \frac{kq}{r^2}$ and A of sphere $= 4\pi r^2$
• $\phi = \frac{kq}{r^2} \times (4\pi r^2)$
• $4\pi k \xrightarrow{r^2} \frac{1}{\varepsilon_0}$ where $\varepsilon_0 = 8.85 \times 10^{-12}\ C^2/Nm^2$
hence, $\phi \ \frac{q_{enc}}{\varepsilon_0}$ $k = \frac{1}{4\pi\varepsilon_0} = 9.0 \times 10^9\ Nm^2/C^2$





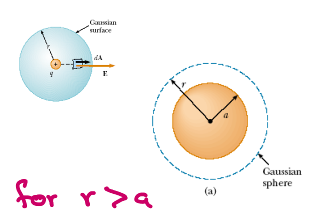


A CHARGED ISOLATED CONDUCTOR:- (not connected) • If an excess charge is placed on an isolated conductor, that amount of charge will move entirely to the surface of the conductor. None of the excess charge will be found within the body of the conductor.
• For an isolated conductor with a cavity, there is no net charge on the cavity walls, all the excess charge remains on the outer surface of the conductor. There is no net charge on the cavity walls as electric field inside a conductor is zero, and if we place our Gaussian surface inside conducto (where the field is zero), the charge enclosed must be zero $(+q-q) = 0$

FORMULAE :- • $\phi = \frac{q_{enc}}{V}$ where V = p.d

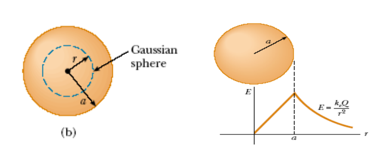
• $E = \frac{\lambda}{2\pi\varepsilon_0 r}$ (E through a cylinder with uniform E)

• $E = \frac{q}{4\pi\varepsilon_0 r^2}$ OR $\frac{kq}{r^2}$ (electric field due to a point charge)



• $E = \frac{q}{4\pi\varepsilon_0 r^2}$ OR $\frac{kq}{r^2}$ (spherically symmetric charge distribution) for $r > a$

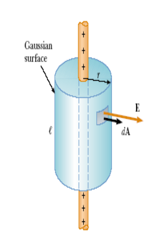
• $E = \frac{kQr}{a^3}$ OR $\frac{\rho r}{3\varepsilon_0}$ (spherically symmetric charge distribution) for $r \leq a$



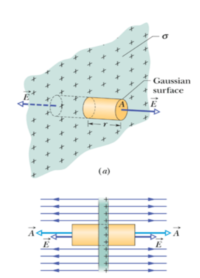
Electric field of a uniformly charged non-conducting sphere increases inside the sphere to a maximum at the surface, and then decreases as 1/r^2

• $E = \frac{kQ}{r^2}$ (electric field due to a thin spherical shell) for $r \geq a$, $E = 0$ for $r < a$
(conducting sphere with charge outside)

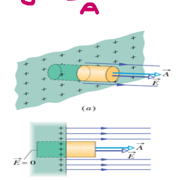
• $E = = \frac{2k\lambda}{r}$ (electric field due to a cylindrical symmetric charge distribution)
where $\lambda = \frac{q}{L}$



• $E = \frac{\delta}{2\varepsilon_0}$ (a non conducting plane of charge)
where δ = density $\longrightarrow$ $\lambda = \frac{q}{L}$ (1D), $\delta = \frac{q}{A}$ (2D), $\rho = \frac{q}{V}$ (3D)



• $E = \frac{\delta}{\varepsilon_0}$ (external electric field of a conductor)



• $q = \delta A$ (when dealing with uniformly charged surfaces (charge per unit A $\times$ A))