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GAUSS LAW (గాస్ నియమము)

Some basic points:

Electric field(E) { విద్యుత్ క్షేత్రం}:

The region surrounding a charge or a group of charges, in which another charge experiences a force is called as "Electric Field".

ఒక విద్యుదావేశం లేదా విద్యుదావేశ సమూహం చుట్టూ వేరొక విద్యుదావేశం పై బలం పనిచేసే ప్రదేశాన్ని

విద్యుత్ క్షేత్రం అంటారు

It is represented by 'E'.

Electric Flux(Φ_E) { విద్యుత్ భ్రామకము}:

The concept of **flux** describes how much of something goes through a given area. More formally, it is the dot product of a vector field with an area. Therefore, Electric flux is a measure of the number of electric field lines passing through an area. Further, one can say that larger the area, the more field lines go through it i.e., the greater the flux. Furthermore, strong electric field means greater electric flux.

ఒక తలం పై ప్రమాణ వైశాల్యం కు లంబం గా ద్వారా పోయే విద్యుత్ బలరేఖల సంఖ్యను విద్యుత్ భ్రామకము అంటారు.

Numerically, it says about the "number" of electric field lines passing through an area. The numerical value of the electric flux depends on the magnitudes of the electric field, the area and angel between the area and direction of the electric field. The total electric flux is represented 'Φ_E' which is given by

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$$\Phi_E = \oint E.\Delta S = E.S$$

If θ is the angle between E and ΔS, the scalar product is given by E.ΔS= EΔScosθ

The electric flux $\Phi_E = \oint E.\Delta S cos\theta$ or $\Phi_E = Ecos\theta \oint \Delta s = Ecos\theta A$ $(\oint \Delta S = A)$

$$\therefore \Phi_E = EAcos\theta$$

Gauss Law:

It is the converse of Coulomb's law. Coulomb's law is useful for calculation of Electric field(E).

Gauss law is useful to determine charge if Electric field is known.

Statement: The total normal electric flux Φ_E over a closed is equal to $(1/\varepsilon_o)$ times the total charge Q enclosed within the surface.

ఒక సంవృత తలం లో తలమునకు లంబం గా పని చేసే విద్యుత్ క్షేత్ర బ్రామకం విలువ తలం లోని మొత్తం విద్యుదావేశము మరియు $(1/\varepsilon_o)$ లబ్ధమునకు సమానం

PROOF OF GAUSS LAW(గాస్ నియమనిరూపణ):

When the charge is within the surface:

Let +Q is placed at 'O' within a closed surface of an arbitrary shape as shown in the following figure. Con sider a point P in the surface at a distance of 'r' from 'O'. further, consider a small are dS around 'P'. the normal to the surface is represented by a vector **dS** which makes an angle θ with the direction of Electric field(E) along OP. the electric flux $d\Phi_E$ outwards through the area dS is given by

$\Phi_E = E.dS = EdScos\theta$ (θ is the angle between E and dS) ----------(1)

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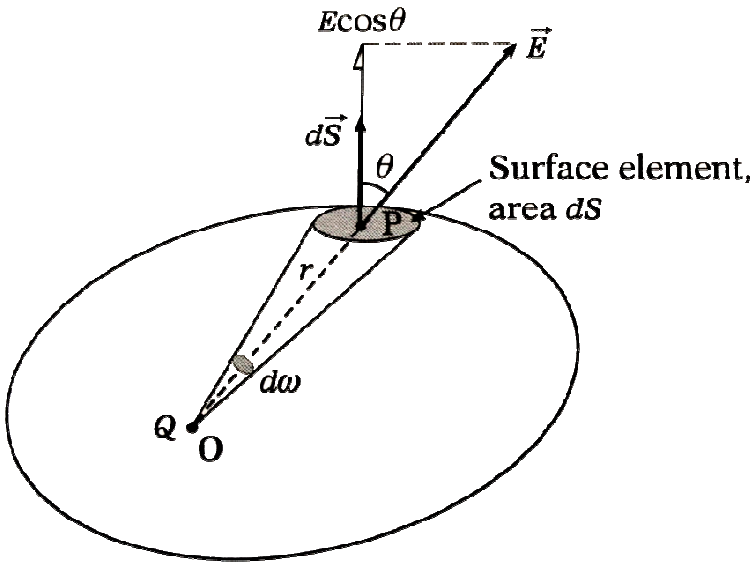

From Coulomb's law, the electric field E at point P, distance r is given by

$$E = \frac{1}{4\pi\varepsilon_0}\left[\frac{Q}{r^2}\right] \qquad \text{-----(2)}$$

From equations (1) and (2), one can write

$$d\Phi_E = \frac{Q}{4\pi\varepsilon_0 r^2}\,.\,\mathrm{dScos\theta} = \frac{Q}{4\pi\varepsilon_0}\left[\frac{\mathrm{dScos\theta}}{r^2}\right] = \frac{Q}{4\pi\varepsilon_0}\,\mathrm{d\omega}$$

$$\left[\because \frac{dS\cos\theta}{r^2} \;\; is\ the\ solid\ angle\ d\omega \;\; by\ dS\ at\ O\right]$$

The total electric flux Φ_E over the whole surface is given by

$$\Phi_E = \frac{Q}{4\pi\varepsilon_0}\oint d\omega$$

$$[here, \oint d\omega \;\; is\ the\ solid\ angel\ subtended\ by\ the\ whole\ surface \;\; at \;\; O \;\; which\ is\ equal\ to\ 4\pi]$$

Therefore, $\Phi_E = \frac{Q}{4\pi\varepsilon_0}\,4\pi = \frac{Q}{\varepsilon_0}$ -----(3)

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When the closed surface encloses several charges say, $+Q_1$, $+Q_2$, $+Q_3$,--------, $-Q_1$, $-Q_2$, $-Q_3$,…..etc.,..

In this case, all the charges contribute in the term total flux. Here, the flux due to the positive charge will be outward and the flux due to negative charge will be inward.

Therefore, the total flux Φ_E is given by

$$\Phi_E = \frac{1}{\varepsilon_0}\sum Q \qquad where, \sum Q \ is\ the\ algebraic\ sum\ of\ all\ charges \qquad \text{------(4)}$$

Hence, one can conclude that the total normal electric flux over a closed surface is equal to $(1/\varepsilon_0)$ times the total charges enclosed within the surface which proves Gauss law.

Some frequently asked questions

1. State and prove Gauss law
2. State and prove Gauss law in electrostatics.
3. Derive Gauss law in electrostatics
4. With the help of a closed charged surface, prove Gauss law
5. The total normal electric flux Φ_E over a closed is equal to $(1/\varepsilon_o)$ times the total charge Q enclosed within the surface. Prove it.
6. What is electric flux? Explain.

References:

1. *Unified Physics, Volume III, JAI PRAKASH NATH PUBLICATIONS, MEERUT*

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