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Electric physics II
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2020 - 2021

Electric physics II
Electric flux& Gauss's law

By

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Summary

- Electric Flux
- Gauss's Law
- Examples of using Gauss's Law
- Properties of Conductors

Flux of an electric field

- Is the measure of electric field line passing through the surface area “S”

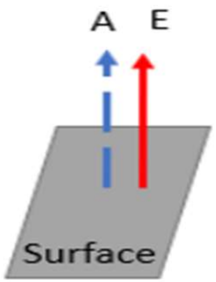
Electric flux

$\phi = E \times A$ unite : N.m^2/C

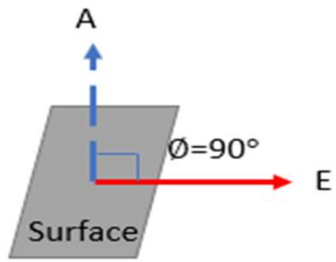
Where:

A: is a vector perpendicular to the surface area ,

E : is the electric field

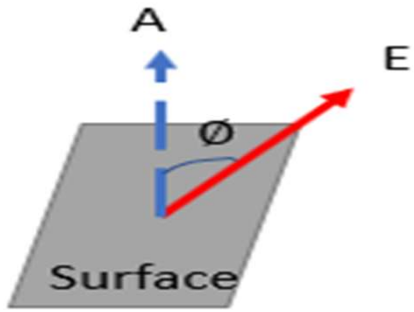


(A) parallel to the (E)



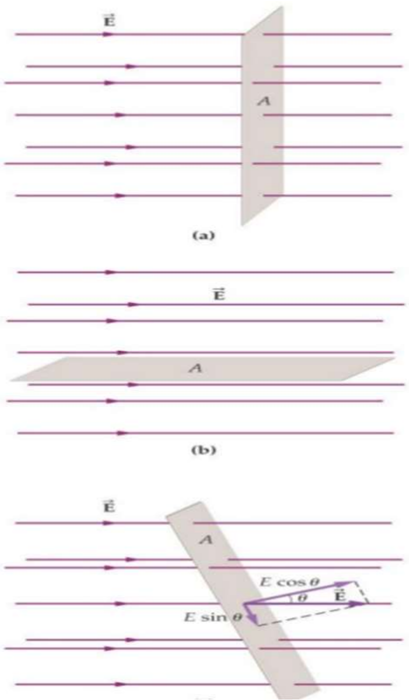
(A) perpendicular to the(E)

- Electric flux depend on the strength of the E on the surface area , and depend on the relative orientation of the field and the surface (∅



$\phi = E \times A \cos \emptyset$

Where ∅ is the angle between E and A



Calculate the flux of the electric field E, through the surface A, in each of the three cases shown:

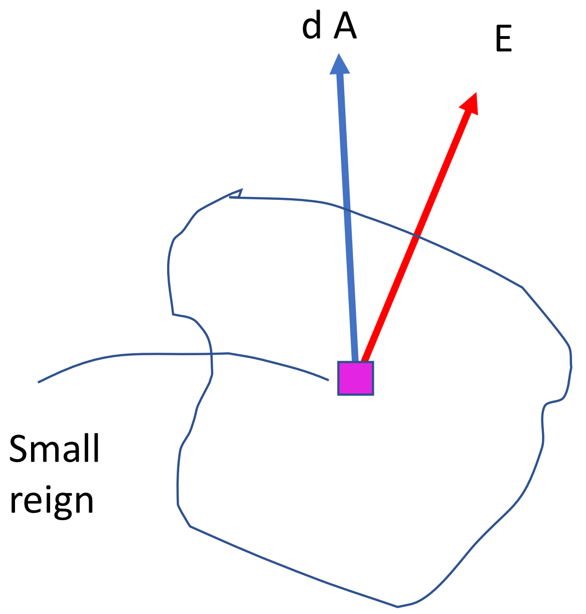
a) $\Phi =$
b) $\Phi =$
c) $\Phi =$

Gauss's Law

- Gauss' law is an expression of the general relationship between the net electric flux through a closed surface and the charge enclosed by the surface. The closed surface is often called a Gaussian surface.

Gaussian surface : The closed surface is often called a Gaussian surface. If the Gaussian surface has a net electric charge q_{in} within it, then the electric flux through the surface is q_{in} / ε_0, that is

$$\Phi = \oint E.dA = \frac{Q_{in}}{\varepsilon_0}$$



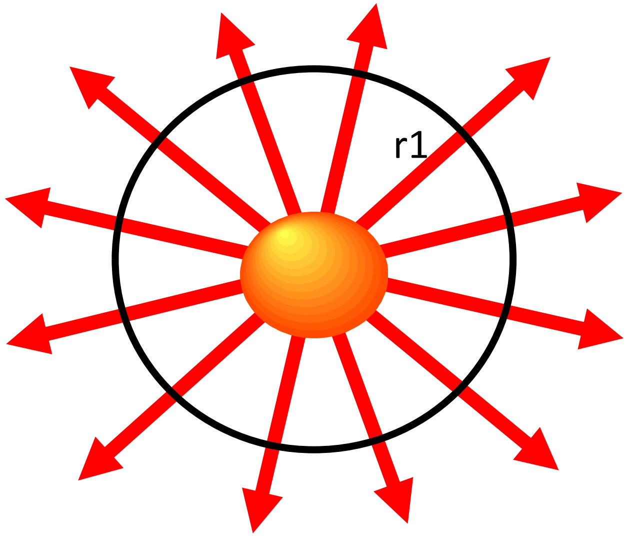
Flux through a sphere from a point charge

The electric field around a point charge

$$|\mathbf{E}| = \frac{1}{4\pi\varepsilon_0}\frac{Q}{|\mathbf{r}_1|^2}$$

Thus the flux on a sphere is E × Area

$$\Phi = \frac{1}{4\pi\varepsilon_0}\frac{Q}{|\mathbf{r}_1|^2} \times 4\pi|\mathbf{r}_1|^2$$



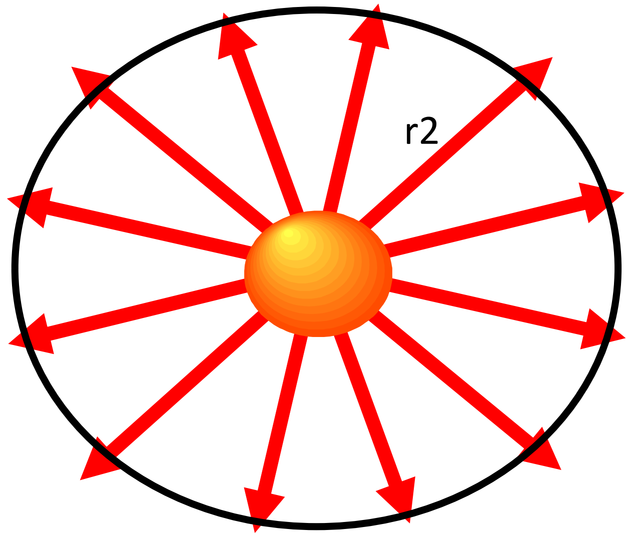
Cancelling we get

$$\Phi = \frac{Q}{\varepsilon_0}$$

Now we change the radius of sphere

$$|\mathbf{E}| = \frac{1}{4\pi\varepsilon_0}\frac{Q}{|\mathbf{r}_2|^2}$$

$$\Phi_2 = \frac{1}{4\pi\varepsilon_0}\frac{Q}{|\mathbf{r}_2|^2} \times 4\pi|\mathbf{r}_2|^2$$

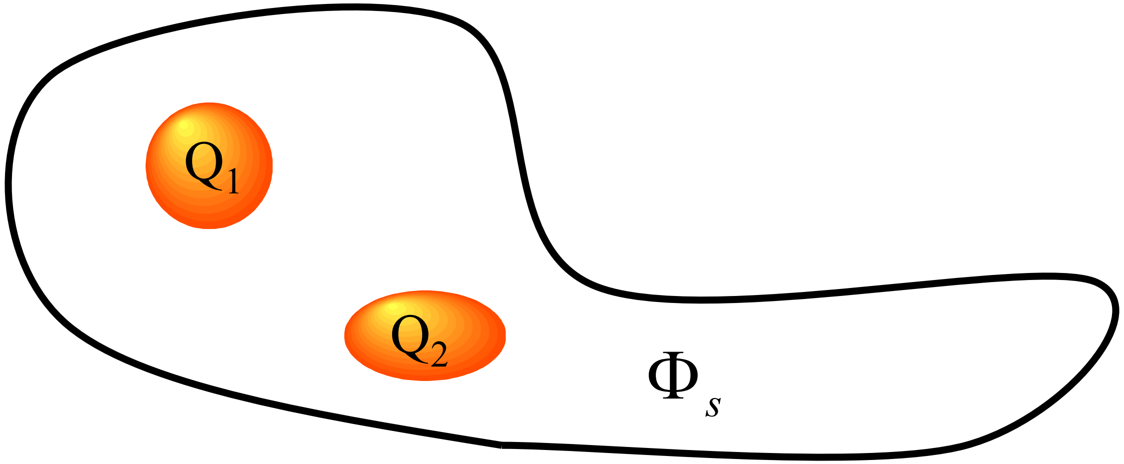


$$\Phi_2 = \frac{Q}{\varepsilon_0}$$

The flux is the same as before

$$\Phi_2 = \Phi_1 = \frac{Q}{\varepsilon_0}$$

Since the flux is related to the number of field lines passing through a surface the total flux is the total from each charge



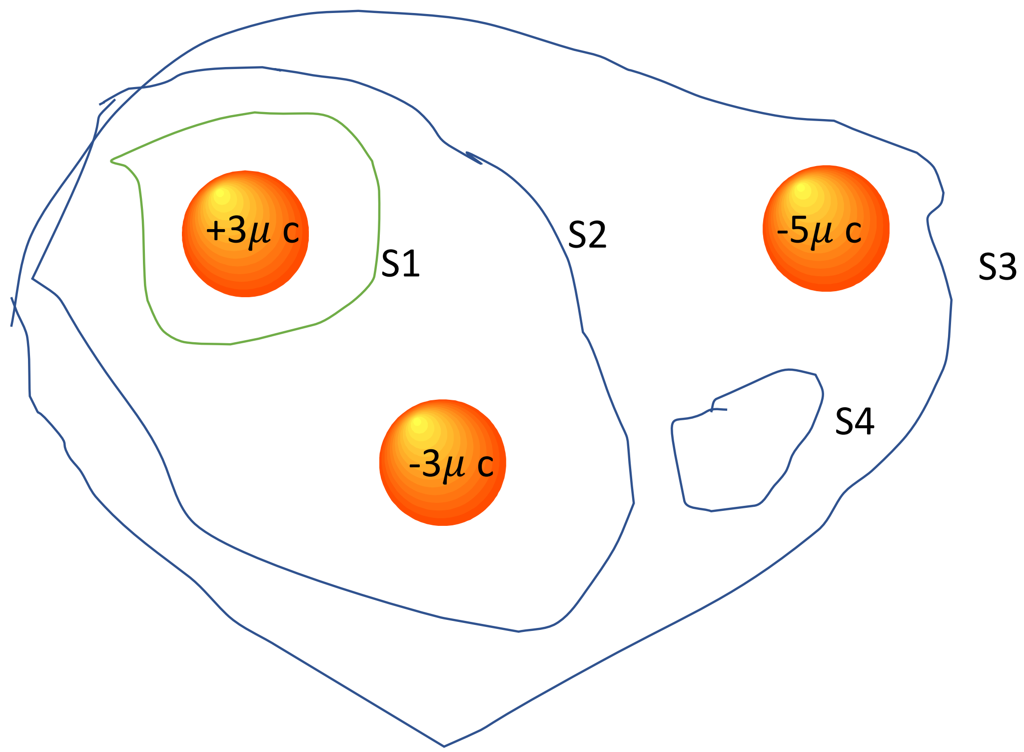
$$\Phi_S = \frac{Q_1}{\varepsilon_0} + \frac{Q_2}{\varepsilon_0}$$

$$\Phi_S = \sum \frac{Q_i}{\varepsilon_0}$$

For any surface

Gauss's Law

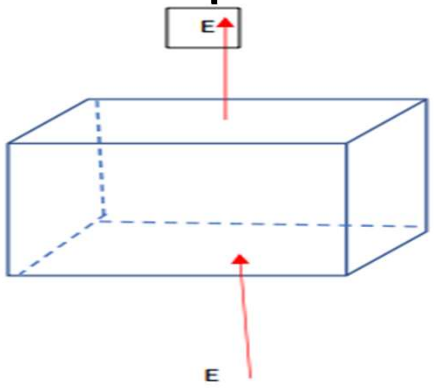
Quiz:-



Quiz)
Calculate the electric flux in each closed surface

ϕ_{s1}=
ϕ_{s2}=
ϕ_{s3}=
ϕ_{s4}=

Example



Find the flux in each surface if the electric field is pass through the closed surface and its direction as shown in figure ?

1- electric flux on the upper surface is

$$\Phi_{out} = +E\ A$$

Because E ∥ *the line perpendecoler to* A and its sign is positive (E is pointing outward the surface)

2- electric flux on the lower surface is

$$\Phi_{in} = -E\ A$$

Because E ∥ *the line perpendecoler to* A and its sign is negative (E is pointing inward the surface)

3- the electric flux on the other 4-surface of the cubic is 0 Because E ⊥ *the line perpendecoler to* A

$$\Phi = E\ A \cos 90 = 0$$

4-The net Φ is $\Phi_{net} = \Phi_{in} + \Phi_{out}$

$$\Phi_{net} = -E\ A + EA = 0$$

$$\Phi_{in} = \Phi_{out} \text{(but in the opposite direction)}$$

Conductors in Electric Fields

- E = 0 everywhere inside the conductor.
- 2. There is no net charge inside the conductor.
- 3. E is everywhere perpendicular to the bounding surface of the conductor.
- 4. The electric potential V is constant insider the conductor.
- 5. Any net charge must reside on the surface of conductor.
- 6. The tangential component of the electric field E is zero on the surface of conductor.

1-E is zero within conductor

If there is a field in the conductor, then the free electrons would feel a force and be accelerated. They would then move and since there are charges moving the conductor would not be in electrostatic equilibrium
Thus E=0

2. There is no net charge inside the conductor.

Because of the repulsive force inside the conductor the charge would reside on the surface of conductor

3-E is everywhere perpendicular to the bounding surface of the conductor.

If the tangential component of the $E_{||} > 0$, it would cause surface charge q to move thus it would not be in electrostatic equilibrium, thus $E_{||} = 0$, for this reason only the vertical component of E bounded the surface of conductor