جامعة الموصل
كلية العلوم – قسم الفيزياء

المستوى الاول

المقرر 103

مبادئ الكهربائية والمغناطيسية

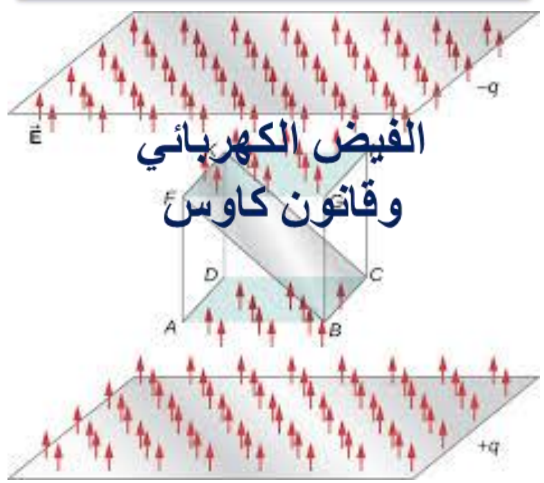
الاستاذ الدكتور

ليث محمد الطعان

٢٠١٩-٢٠٢٠

Prof. Dr. Laith Al-Taan

الفيض الكهربائي
وقانون كاوس



Electric Flux

When the electric field lines penetrate تخترق a surface of area A, which is perpendicular عمودية to the field , as shown in the figure1:

The number of field lines is proportional تتناسب **to the *product* of *E* and *A*, called the**

electric flux: $\boxed{\Phi = E\,S}$ the unit is : (**N . m2/C**)

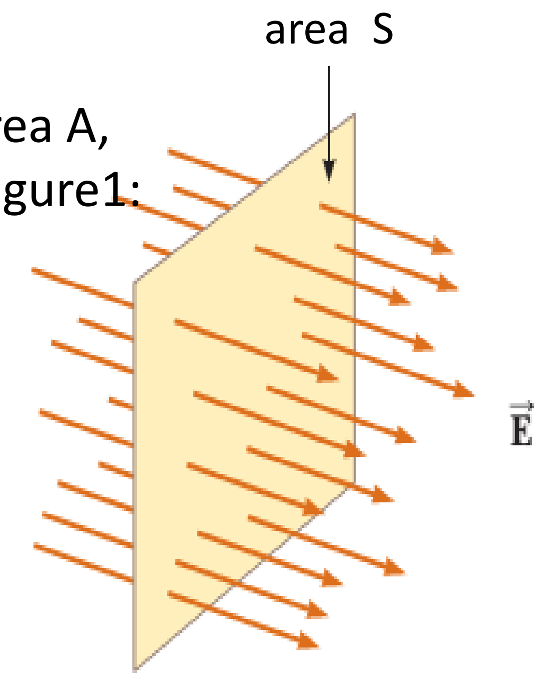
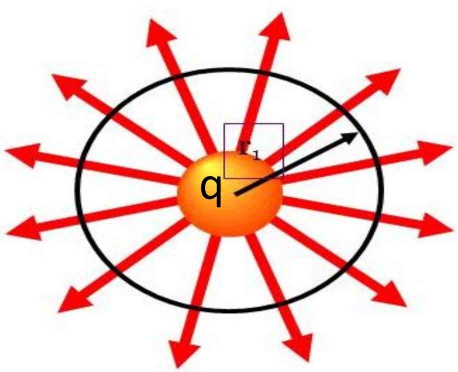


Figure 1

$E = \dfrac{1}{4\pi\varepsilon_0}\dfrac{q}{r^2}$ والان : نفرض ان المجال الناشئ من شحنة نقطية هو:

وسيكون شكل المجال شعاعي حولها عموديا على سطح كروي يحيط بها.

ولان الفيض هو : $\Phi = E\,S$



The electric field around a point charge

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

شدة المجال من الشحنة

Thus the flux on a sphere is E × Area

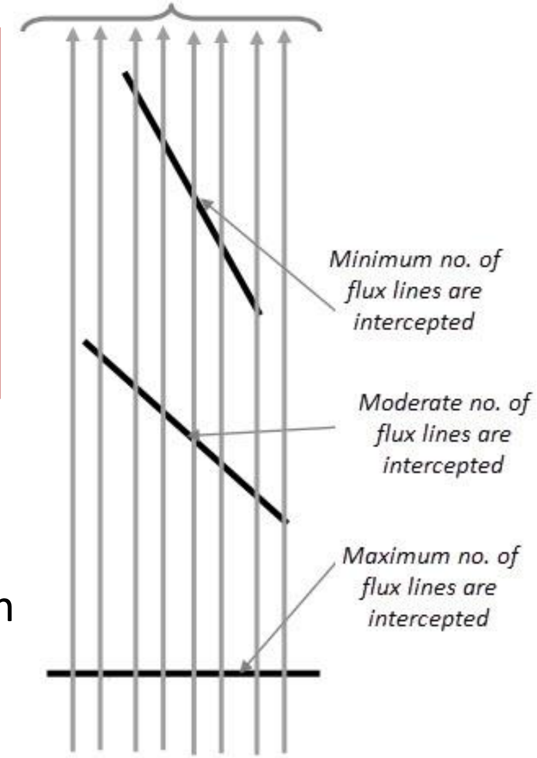
$$\Phi = \underbrace{\frac{1}{4\pi\varepsilon_0}\frac{Q}{|\mathbf{r}_1|^2}}_{E} \times \underbrace{4\pi|\mathbf{r}_1|^2}_{Area}$$

مساحة الكرة التي يخترقها خطوط المجال

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

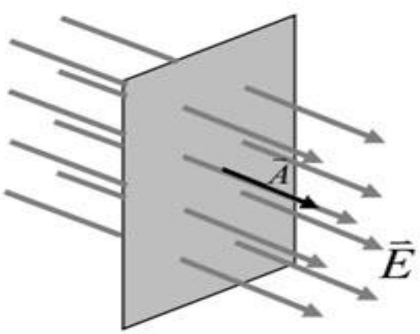
The lines of force passing through a surface of a given area is dependent on three factors:

1. Strength of the Electric Field
2. Area of the Surface
3. Orientation اتجاه وتوجيه of the surface <u>w.r.t</u> the lines of force.

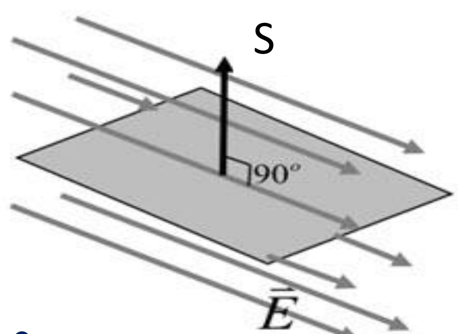


And ,
if the surface is **<u>not</u>** perpendicular ان لم يكن عموديا to the field, as in Figure , then <u>the number of line passing will be proportional to this angle,</u> the expression for the electric flux is:

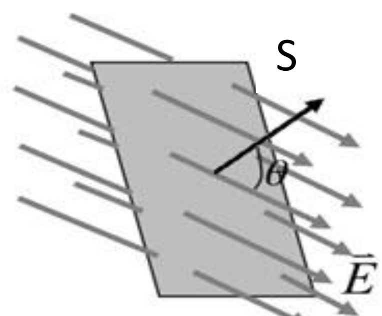
$$\boxed{\Phi = E\, S \cos\theta}$$



$\theta = 0$
$\therefore \Phi$ max



$\theta = 90$
$\therefore \Phi$ min



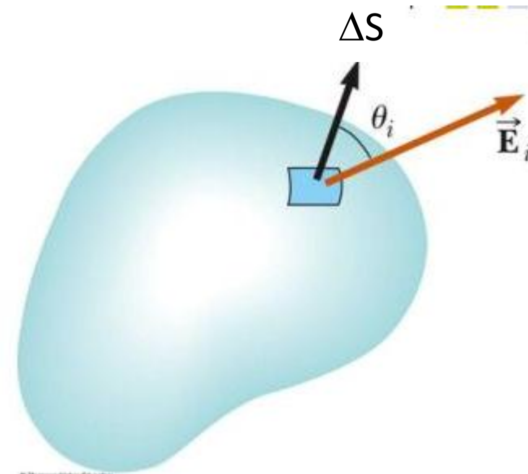
$\therefore \Phi \propto \cos\theta$

والان :

عندما يكون السطح المحيط بالشحنة ليس كرويا / اي ان خطوط المجال الكهربائي لا تسقط عموديا على السطح المحيط بها.

اذن نختار عنصرا تفاضليا من السطح مساحته صغيرة dS

لذا فان الفيض عبر هذا الجزء من المساحة :

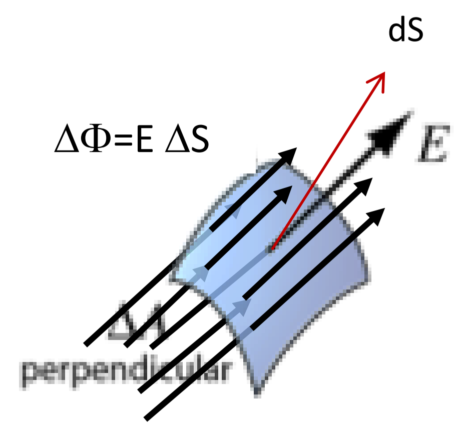


$$d\Phi = \underbrace{E \cos\theta \;\; dS}_{\text{مسقط المساحة على المجال الكهربائي}}$$

وبصيغة المتجهات $\mathbf{d\Phi = \vec{E} \,.\, d\vec{S}}$

$$\Phi = \int E \,.\, dS$$

$$\Phi = \int E \cos\theta \, dS$$

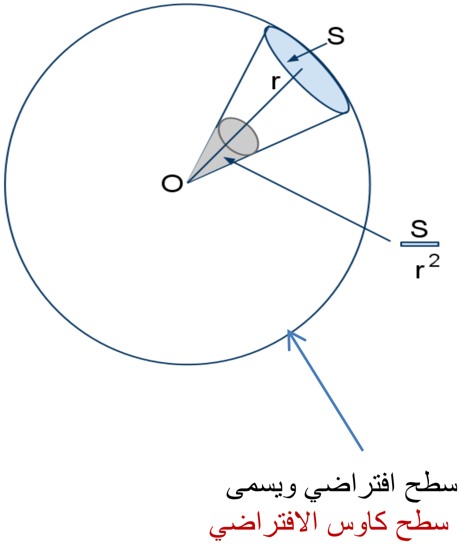


Drive the total electric flux duo to a point charge inside enclosed virtual surface?

نعرف اولا الزاوية المجسمة داخل السطح المنتظم والمغلق.

اذ تعتمد الزاوية المجسمة solid state على مقدار المساحة المقطوعة على السطح الكروي :

$$\Omega = \frac{S}{r^2} \qquad ....(1)$$



ولان السطح مغلق فان وحدتها

$$\Omega = \frac{4\pi r^2}{r^2} \qquad .... \quad (2)$$

ان عنصر الفيض خلال عنصر المساحة يمكن حسابه من المعادلة:

$$d\Phi = E.\ dS = E\cos\theta\ dS \qquad ....(3)$$

$$d\Phi = \frac{q}{4\pi r^2}\frac{dS\cos\theta}{r^2} \ldots\ldots\ldots\ldots \quad (4)$$

$$\Phi = \frac{q}{4\pi r^2}\int d\Omega \qquad ....(5)$$

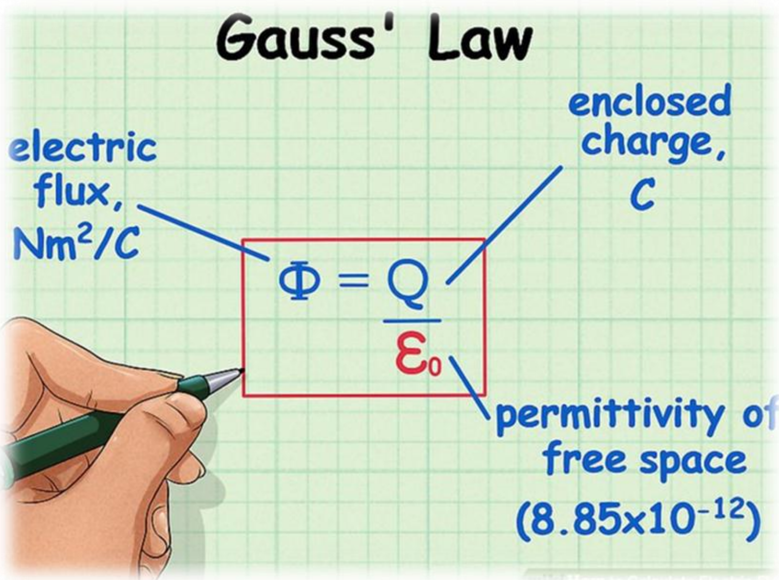
$\therefore$ the total flux through the enclosed surface , $\Phi = = \frac{q}{r^2}$, ... (6)

وهذه العلاقة الاخيرة **<u>تعرف بقانون كاوس</u>** هي الشحنة الكلية المحصورة داخل السطح الافتراضي (سطح كاوس)المغلق.

- Gauss law

$$\Phi_E = \oint \vec{E} \cdot \Delta S = \frac{q_{in}}{\varepsilon_0}$$

q_{in} is the net charge inside the surface



Gauss's law , states that the electric flux through any **closed** surface is equal to the net charge Q **inside** the surface divided by the permittivity of free space, ε_0.

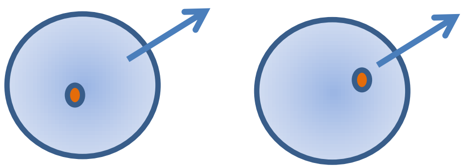
For highly symmetric distributions of charge, Gauss's law can be used to calculate electric fields.

Quiz

Q1// What is the electric flux through a sphere of radius R surrounding a charge +Q at the center?

1) 0
2) $+Q/\varepsilon_0$
3) $-Q/\varepsilon_0$
4) +Q
5) None of these

Q2// How does the flux Φ_E through the entire surface change when the charge +Q is moved from position 1 to position 2?



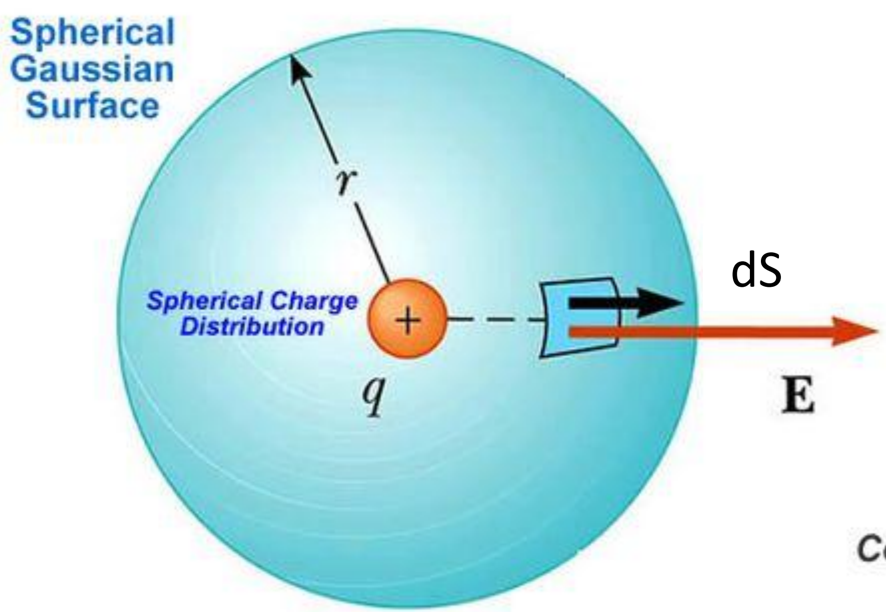
a) Φ_E increases
b) Φ_E decreases
c) Φ_E doesn't change (Just depends on charge not position)

Drive the Coulomb's law from Gauss's law?

E is constant
everwhere on the surface

Electric Flux $$\Phi_E = \oint E \cdot dS = \oint E \, dS = E \oint dS = \frac{q_{in}}{\varepsilon_o}$$

**E and dS are parallel
everywhere on the surface**



$$E(4\pi r^2) = \frac{q_{in}}{\varepsilon_o}$$

surface area
of a sphere

$$E = \frac{q_{in}}{4\pi\varepsilon_o r^2}$$

$$k = \frac{1}{4\pi\varepsilon_o}$$

Coulomb's Law
$$E = \frac{kq_{in}}{r^2}$$

the net flux through any closed surface surrounding a point charge q is given by q/ε_o and its independent of the shape of that surface