Electric Flux

Saturday, June 10, 2023 10:18 AM

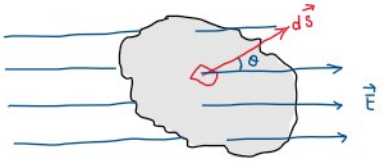
Electric flux :-

The electric flux through a given area held inside an electric field is the measure of the total number of electric field lines of force passing through that area.

SI unit of electric flux is $N\text{-}m^2C^{-1}$ or $J\text{-}mC^{-1}$ or $V\text{-}m$.

CGS unit of electric flux is $dyne\text{-}cm^2/c$

Electric flux is given by the product of surface area and the component of electric field intensity normal to the area.



Electric flux through small area element (ds) is

$$d\phi_E = (E\cos\theta)(dS)$$

$$d\phi_E = EdS\cos\theta$$

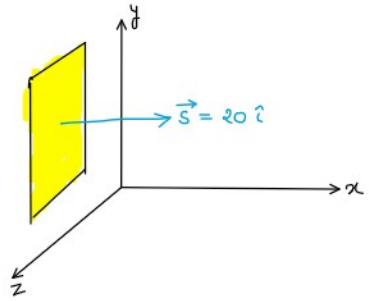
$$\boxed{d\phi_E = \vec{E}\cdot d\vec{S}}$$

The electric flux through the entire surface is :-

$$\boxed{\phi_E = \int_S \vec{E}\cdot d\vec{S}}$$

$$\boxed{\phi_E = \oint_S \vec{E}\cdot d\vec{S}} \rightsquigarrow \text{when surface S is closed surface.}$$

Ques. If the electric Field is given by 6i+3j+4k calculate the electric flux through a surface of area 20 units lying in Yz plane



flux through surface of area 20 units :

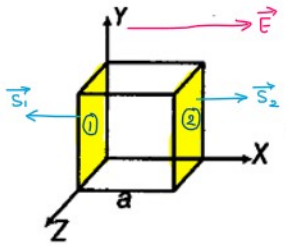
$$\phi_E = \vec{E}\cdot\vec{S}$$

$$\phi_E = (6\hat{i} + 3\hat{j} + 4\hat{k})\cdot(20\,\hat{i})$$

$$\boxed{\phi_E = 120 \text{ units}}$$

Ques. Given the electric field in the region $\vec{E} = 2x\hat{i}$, find the net electric flux through the cube and the charge enclosed by it.

flux through all sides except shaded sides (1 and 2) are zero because angle b/w area vector and electric field vector is zero.



flux for side-1

$$\phi_1 = \vec{E} \cdot \vec{S_1}$$

$$\boxed{\phi_1 = 0}$$

$\theta = 180°$

$S_1 = a^2$

$x = 0$

$E = 2(0) = 0$ N/C

flux for side-2

$$\phi_2 = \vec{E} \cdot \vec{S_2}$$

$$\phi_2 = E S_2$$

$$\boxed{\phi_2 = 2a^3}$$

$\theta = 0°$

$S_2 = a^2$

$x = a$

$E = 2(a) = 2a$ N/C

flux through cube :-

$$\phi_{cube} = \phi_1 + \phi_2 \quad \Rightarrow \quad \boxed{\phi_{cube} = 2a^3}$$

Ques. A circular plane sheet of radius 10cm is placed in a uniform electric field of 5×10^5N C^{-1}, making an angle of 60° with field. The electric flux through the sheet is

$$\phi_E = EA\cos\theta = \vec{E} \cdot \vec{A}$$

$$\boxed{\phi_E = 1.36 \times 10^4 \ Nm^2/C}$$

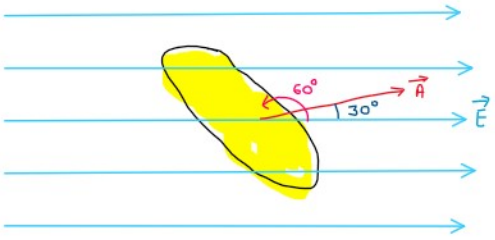
Given :

$\theta = 30°$

$E = 5 \times 10^5$ N/C

$r = 10cm = 0.1$ m

$A = \pi r^2$



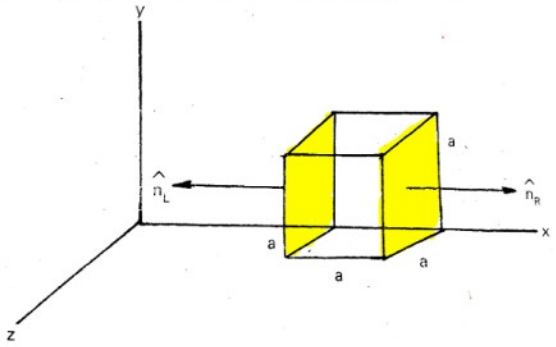
Ques. Consider a uniform electric field $E = 3 \times 10^3 \hat{i}$ N/C.

(a) What is the flux of this field through a square of 10 cm on a side whose plane is parallel to the yz plane?

(b) What is the flux through the same square if the normal to its plane makes a 60° angle with the x-axis?

Do by yourself.

Ques. The electric field components in Fig. are $E_x = ax^{1/2}$, $E_y = E_z = 0$, in which $\alpha = 800 N/Cm^{1/2}$. Calculate the flux through the cube



If a = 0.1 m is the side of cube then the charge within the cube is:

flux through all sides except shaded sides (1 and 2) are zero because angle b/w area vector and electric field vector is zero.

flux for side-1

$$\phi_1 = \vec{E} \cdot \vec{S_1}$$

$$\boxed{\phi_1 = -\alpha a^{5/2}}$$

$\theta = 180°$

$S_1 = a^2$

$x = a$

$E = \alpha (a)^{1/2}$

flux for side-2

$$\phi_2 = \vec{E} \cdot \vec{S}_2$$

$$\phi_2 = E S_2$$

$$\boxed{\phi_2 = \sqrt{2}\alpha a^{5/2}}$$

$\theta = 0°$

$S_2 = a^2$

$x = 2a$

$E = \alpha (2a)^{1/2} = \sqrt{2}\alpha a^{1/2}$

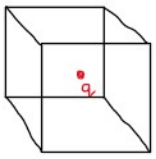
flux through cube :-

$$\phi_{cube} = \phi_1 + \phi_2 \quad \Rightarrow \quad \phi_{cube} = \alpha a^{5/2} (\sqrt{2} - 1)$$

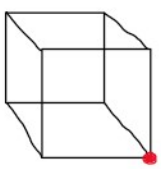
$$\boxed{\phi_{cube} = 1.04 \ Nm^2/C}$$

Ques. Calculate the electric flux through each of the six faces of a closed cube of length l, if a charge q is placed (a) at its centre and (b) at one of its vertices.

(a) $\boxed{\phi_E = \frac{q}{\varepsilon_0}}$



(b)



charge enclosed by cube = q/8

then $\boxed{\phi_E = \frac{q}{8\varepsilon_0}}$

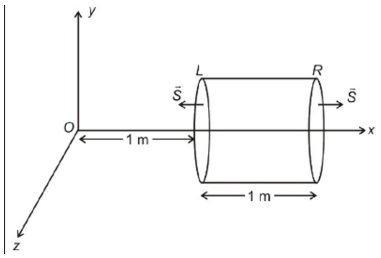
Ques. A hollow cylindrical box of length 1 m and area of cross-section 25 cm^2 is placed in a three dimensional coordinate system as shown in the figure. The electric field in the region is given by $\vec{E} = 50x\hat{i}$, where E is in NC^{-1} and x is in metres.

Find

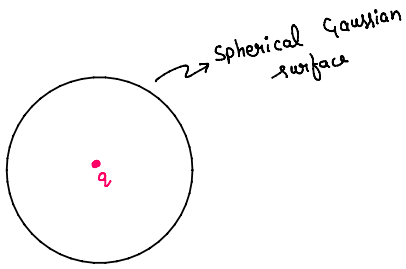
(i) Net flux through the cylinder.

(ii) Charge enclosed by the cylinder.

Do by yourself.



Ques. A spherical Gaussian surface encloses a charge of $8.85 \times 10^{-8} C$ (i) Calculate the electric flux passing through the surface (ii) If the radius of Gaussian surface is doubled, how would the flux change ?



(i) According to Gauss Law :-

$$\phi_E = \frac{\text{charge enclosed by gaussian surface}}{\varepsilon_0} \quad \text{---(1)}$$

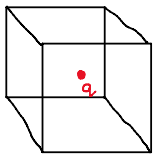
$$\phi_E = \frac{8.85 \times 10^{-8}}{8.85 \times 10^{-12}} \Rightarrow \boxed{\phi_E = 10^4 \ Nm^2/C}$$

(ii) from eq^n (1) ; flux does not depend on radius of sphere . Hence no change in flux.

Ques. **A point charge $17.7 \mu C$ is located at the centre of the cube of side 0.03 m Find the electric flux through each face of the cube.**

flux through cube :-

$$\phi_E = \frac{q}{\varepsilon_0}$$



$q = 17.7 \mu C = 17.7 \times 10^{-6} C$

flux through each side of cube :-

$$\boxed{\phi'_E = \frac{q}{6\varepsilon_0} = 3.3 \times 10^5 \ Nm^2/C}$$

Ques. The electric field components due to a charge inside the cube of side 0.1 m are shown in figure.

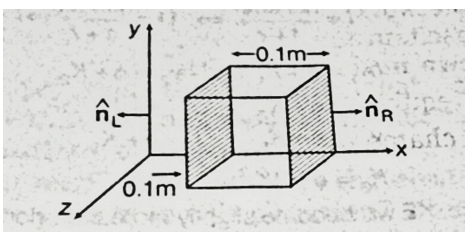
where, $E_x = \alpha$, where $\alpha = 500$ N/C-m, $E_y = 0$, $E_z = 0$.

Calculate

(a) the flux through the cube and

(b) the charge inside the cube.

Do by Yourself



Ques. Given a uniform electric field $\vec{E} = 5 \times 10^3 \hat{i} N/C$, find the flux of this field through a square of 10 cm on a side whose plane is parallel to the y-z plane. What could be the flux through the same square if the plane makes $30°$ angle with the x-axis? Do by yourself.