A point charge of $1\mu C$ is at the centre of a Cubical Gaussian surface 55cm on edge. What is the net electric flux through the surface.

SOLUTION:

$q = 1.8\,\mu C \qquad (1\mu C = 10^{-6} C)$

or $q = 1.8 \times 10^{-6} C$

Permittivity of free space $= \epsilon_0 = 8.85 \times 10^{-12} \dfrac{C^2}{N\text{-}m^2}$

$r = 55\,cm$

$\phi = ?$

By Gauss' law, $\phi = \dfrac{q}{\epsilon_0}$

$\phi = \dfrac{1.8 \times 10^{-6}}{8.85 \times 10^{-12}} = 2 \cdot 10^{5}\ N\text{-}m^2/C^2$

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A uniformly charged conducting sphere of 1.2 m diameter has a surface charge density of 8.1 $\mu c/m^2$.

Find the charge on the sphere.

What is the total electric flux leaving the surface of the sphere?

SOLUTION :

$d = 1.2\ m$

$r = \frac{d}{2} = \frac{1.2}{2} = 0.6\ m$

$\sigma = 8.1\ \mu c/m^2$ $\quad (1\ \mu c = 10^{-6} c)$

or $\sigma = 8.1 \times 10^{-6}\ c/m^2$

(a) $q = ?$

Area of sphere $= A = 4\pi r^2$

$A = 4 \times 3.14 \times (0.6)^2 = 4.52\ m^2$

$q = \sigma \times A \quad (\because \sigma = \frac{q}{A})$

$= 8.1 \times 10^{-6} \times 4.52$

$q = 36.61 \times 10^{-6}\ C$

(b) Flux $= \phi = ?$

$\epsilon_0 = 8.85 \times 10^{-12}\ C^2/N\text{-}m^2$

By Gauss' law,

$$\phi = \frac{q}{\epsilon_0}$$

$$\phi = \frac{36.61 \times 10^{-6}}{8.85 \times 10^{-12}} = 4.1 \times 10^{6}\ N\text{-}m^2/C$$

PROBLEM: 6

An infinite line of charge produces a field of 4.5×10^{4} N/C at a distance of 2.0 m. Calculate the linear charge density.

SOLUTION:

$$E = 4.5\times10^{4}\ N/C$$

$$r = 2.0\ m$$

Linear charge density $= \lambda = ?$

$$\epsilon_0 = 8.85\times10^{-12}\ C^2/N\text{-}m^2$$

we know that

$$\lambda = 2\pi\epsilon_0 E r$$

$$= 2\times3.14\times8.85\times10^{12}\times4.5\times10^{4}\times2.0$$

$$= 5.0\times10^{-6}\ C/m$$

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PROBLEM : 7

A square metal plate of edge length 8.0 cm and negligible thickness has a total charge of 6×10^{-6}c.

(a) Estimate the magnitude E of the electric field just off the center of the plate (at, say, a distance of 0.5 mm) by assuming that the charge is spread uniformly over the two faces of the plate.

(b) Estimate E at a distance of 30m (large relative to the plate size) by assuming that the plate is a point charge.

SOLUTION:

$$\text{Edge length} = L = 8.0\ cm = 0.08\ m$$

$$\text{Area} = L\times L = L^2 = (0.08)^2$$

$$q = 6.0\times10^{-6}$$

$$\epsilon_0 = 8.85\times10^{-12}\ C^2/N\text{-}m^2$$

(a) $E = ?$

$$\text{Area charge density} = \sigma = \frac{q}{2A}$$

$$\sigma = \frac{6.0\times10^{-6}}{2\times(0.08)^2} = 4.69\times10^{-4}\ C/m^2$$

$$E = \frac{\sigma}{\epsilon_o}$$

$$E = \frac{4.69\times10^{-4}}{8.85\times10^{-12}} = 5.3\times10^{7}\ N/C$$

(b) $E = ?$

$r = 30\ m$

As plate is a point charge.

$$E = \frac{1}{4\pi\epsilon_o}\times\frac{q}{r^2}$$

$$E = \frac{1}{4\times3.14\times8.85\times10^{-12}}\times\frac{6.0\times10^{-6}}{(30)^2}$$

$$E = 60\ N/C$$

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PROBLEM : 8

A proton with speed $V=3.00\times10^5$ m/s orbits just outside a charged sphere of radius $r=1.00$ cm. What is the charge on the sphere?

SOLUTION :

Mass of proton $= m = 1.67\times10^{-27}$ Kg

Charge on the proton $= e = 1.60\times10^{-19}$ C

$v = 3.00\times10^{5}$ m/s

Radius of the sphere $= r = 1.00$ cm

or $r = 0.01$ m

$\epsilon_o = 8.85\times10^{-12}\ C/N\text{-}m^2$

Charge on the sphere $= q = ?$

Coulomb's force = Centripetal force

$$\frac{1}{4\pi\epsilon_0} \times \frac{e \times q}{r^2} = \frac{mv^2}{r}$$

or $$\frac{1}{4\pi\epsilon_0} \frac{e \times q}{r} = mv^2$$

$$\frac{1}{4 \times 3.14 \times 8.85 \times 10^{-12}} \times e \times q = mv^2$$

or $$q = \frac{4 \times 3.14 \times 8.85 \times 10^{-12} \times mv^2 \times r}{e}$$

$$q = \frac{4 \times 3.14 \times 8.85 \times 10^{-12} \times 1.67 \times 10^{-27}}{1.60 \times 10^{-19}} \frac{(3 \times 10^5)^2 \times}{0.01}$$

$$q = 1.04 \times 10^{-9}\ C$$