NCERT SOLUTIONS
CLASS-XII PHYSICS
CHAPTER-1
ELECTRIC CHARGES AND FIELDS

Q.1) Two small charged spheres having charges of 2×10^{-7}C and 3×10^{-7}C are placed 30 cm apart in air. What will be the force between these two charges?

Soln.. Given,

Charge on 1st sphere, $q_1 = 2 \times 10^{-7}$ C

Charge on 2nd sphere, $q_2 = 3 \times 10^{-7}$ C

Distance between the two charges, r = 30cm = 0.3m

Electrostatic force between the spheres is given by :

$F = \frac{1}{4\pi\epsilon_o} \cdot \frac{q_1 q_2}{r^2}$

Here,

ϵ_o = permittivity of free space and,

$\frac{1}{4\pi\epsilon_o} = 9 \times 10^9$ Nm^{2}C^{-2}

Force, $F = \frac{9\times10^9\times2\times10^{-7}}{(0.3)^2} = 6 \times 10^{-3}$ N.

Since, the charges are having same nature, therefore, force between them will be repulsive.

Q.2) Two small spheres having charges 0.4 µC and – 0.8 µC in air have electrostatic force of 0.2N.

(1) Find the distance between the two spheres?

(2) What will be the force on the second sphere due to first sphere?

Soln.:

Given,

(1) Charge on 1st sphere, $q_1 = 0.4\ \mu C = 0.4 \times 10^{-6}$ C

Charge on 2nd sphere, $q_2 = -0.8\ \mu C = -0.8 \times 10^{-6}$C

Electrostatic force on the 1st sphere, F = 0.2N

Electrostatic force between the spheres is given by :

$F = \frac{1}{4\pi\epsilon_o} \cdot \frac{q_1 q_2}{r^2}$

Here,

ϵ_o = permittivity of free space and,

$\frac{1}{4\pi\epsilon_o} = 9 \times 10^9$ Nm^{2}C^{-2}

$r^2 = \frac{1}{4\pi\epsilon_o} \cdot \frac{q_1 q_2}{F}$

$= \frac{0.4\times10^{-6}\times8\times10^{-6}\times9\times10^9}{0.2} = 144 \times 10^{-4}$

$r = \sqrt{144 \times 10^{-4}} = 12 \times 10^{-2} = 0.12$m

Distance between the two spheres = 0.12 m

(2) Since, the spheres are having opposite charge, the force on second sphere due to first sphere will also be 0.2N.

Q.3) Identify the given ratio $ke^2/G\, m_e m_p$ as dimensionless quantity or not. From the table of Physical Constants determine the value of this ratio. Also mention the signification of the ratio.

Soln.:

The ratio is given as :

$\frac{ke^2}{Gm_e m_p}$

G = gravitational constant in N m^2 kg^{-2}

m_e and m_p = masses of electron and proton in kg.

e = electric charge. (unit – C)

k = $\frac{1}{4\pi\epsilon_o}$ (unit – Nm^2C^{-2})

Therefore, unit of given ratio,

$\frac{ke^2}{Gm_e m_p} = \frac{[Nm^2C^{-2}][C^{-2}]}{[Nm^2kg^{-2}][kg][kg]}$ = $M^0L^0T^0$

So, the given ratio is dimensionless.

Given,

e = 1.6 x 10^{-19} C

G = 6.67 x 10^{-11} N m^2 kg^{-2}

m_e = 9.1 x 10^{-31} kg

m_p = 1.66 x 10^{-27} kg

Putting the above values in the given ratio,

$\frac{ke^2}{Gm_e m_p} = \frac{9\times10^9\times(1.6\times10^{-19})^2}{6.67\times10^{-11}\times9.1\times10^{-31}\times1.67\times10^{-27}}$ = 2.3 x 10^{39}

So, the above ratio is the ratio of the electric force to the gravitational force between a proton and an electron when the distance between them is constant.

Q.4) (i) 'electric charge of a body is quantised', explain the statement.

(ii) While dealing with macroscopic i.e., large scale charges we can ignore quantisation of charge. Why?

Soln.:

(i) Electric charge of a body is quantized meaning only integral (1, 2, …n) number of electrons can be transferred from a body to another.

Charges do not get transferred infractions. Hence, the total charge possessed by a body is only in integral multiples of electric charge.

(ii) In the case of large scale or macroscopic charges, the charge which are used over there are comparatively too huge to the magnitude of the electric charge. Hence, on a macroscopic level the quantization of charge is of no use Therefore, it is ignored and the electric charge is considered to be continuous.

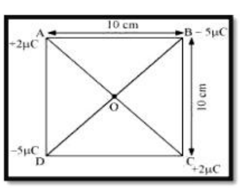
Q 5. Whenever we rub a glass rod with a silk cloth, then a charge appears on both. We can observe this similar phenomenon on a lot of other pair of materials. Explain this phenomenon. How can we relate this observation with the law of conservation of charge?

Soln.:

When we rub two bodies together then a charge is developed on both of the bodies and the charge developed over the bodies are equal but opposite in nature. And this phenomenon of getting a charge is called as charge by friction. The net charge on both of the bodies is 0 and the reason behind it is that an equal amount of charge is also repelling it. When we rubbed the glass rod with the silk cloth, there will be charge with opposite magnitude is generated over there. This phenomenon is in consistence with the law of conservation of energy. A similar phenomenon is observed with many other pairs of bodies.

Q 6. We have four point charges $q_A = 2\mu C,\ q_B = -5\mu C,\ q_C = 2\mu C,\ and q_D = -5\mu C$, which are located at the sides of a square which is of 10 cm side. Calculate the amount of force applied on a charge of $1\ \mu C$ when it is placed at the centre of of the square?

Soln.:



In the above picture we have shown the square mentioned in the question. Whose side is 10 cm and four charges are placed at the corners of the squares. And O is the centre of the square.

Where,

(Sides) AB = BC = CD = DA = 10 cm

(Diagonals) AC = BD = $10\sqrt{2}\ cm$

AO = OC = DO = OB = $5\sqrt{2}\ cm$

At the centre point 'O', we have placed a charge of $1\ \mu C$

In the above case the repulsive force between the corner A and the centre O is same in magnitude with the repulsive force by the corner C to the centre O, but these forces are opposite in direction. Hence, these forces will cancel each other and from A and C no forces are applied on the centre O. Similarly from the corner C the attractive force is applying on to the centre O and another force with the same magnitude is applying on the centre O, also these two forces are opposite in direction hence it is also opposing each other.

Therefore, the net force applying in the centre is zero. Because all the forces here are being cancelled by each other.

Q 7. (i) Explain why an electric field cannot have a sudden break? Explain why "An electrostatic field is a continuous curve"

(ii) Can two field line cross each other? Explain why?

Soln.:

(i) When a charge is placed in an electrostatic field then it experiences a continuous force. Therefore, an electrostatic field line is a continuous curve. And a charge moves continuously and does not jump from on point to the other. So, the field line cannot have a sudden break.

(ii) if two field lines will cross each other at any point then at that point the field intensity will start shooing two directions at a same point which is impossible. Therefore, two field lines can never cross each other.

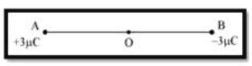
Q 8. We have two point charges on is $q_A = 3\ \mu C$ and other is $q_A = -3\ \mu C$ and the distances between these two charges are 20 cm and these are placed inside a vacuum.

(i) Let us consider O as the mid – point of the line. Then, measure the electric field at the point O of the line AB joining the two charges.

(ii) If we will place a negative charge having a magnitude of $1.5 \times 10^{-9}\ C$ at this point, then calculate the force experienced by the test charge?

Soln.:

(i) Figure given below shows the situation given to us, in which AB is a line and O is the mid – point.



Distance between two charges, AB = 20 cm

Therefore, AO = OB = 10 cm

Total electric field at the centre is (Point O) = E

Electric field at point O caused by $+3\ \mu C$ charge,

$E_1 = \frac{1}{4\pi\epsilon_0} \cdot \frac{3\times10^{-6}}{(OA)^2} = \frac{1}{4\pi\epsilon_0} \cdot \frac{3\times10^{-6}}{(10\times10^{-2})^2} NC^{-1}$ along OB

Where ϵ_0 = Permittivity of free space and $\frac{1}{4\pi\epsilon_0} = 9 \times 10^9\ Nm^2C^{-2}$

Therefore,

Electric field at point O caused by $-3\ \mu C$ charge,

$E_2 = \left| \frac{1}{4\pi\epsilon_0} \cdot \frac{-3\times10^{-6}}{(OB)^2} \right| = \frac{1}{4\pi\epsilon_0} \cdot \frac{3\times10^{-6}}{(10\times10^{-2})^2} NC^{-1}$ along OB

$\therefore E_1 + E_2 = 2 \times \frac{1}{4\pi\epsilon_0} \cdot \frac{3\times10^{-6}}{(10\times10^{-2})^2}\ NC^{-1}$ along OB

[Since the magnitudes of $E_1\ and\ E_2$ are equal and in the same direction]

$\therefore E = 2 \times 9 \times 10^9 \times \frac{3\times10^{-6}}{(10\times10^{-2})^2}\ NC^{-1}$ along OB

$= 5.4 \times 10^6 NC^{-1}$

Therefore, the electric field at mid – point O is $5.4 \times 10^6 NC^{-1}$ along OB.

(ii) A test charge of amount $1.5 \times 10^{-9}\ C$ is placed at mid – point o.

$q = 1.5 \times 10^{-9}\ C$

Force experienced by the test charge = F

Therefore, F = qE

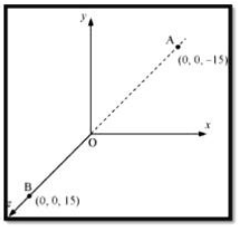
= $1.5 \times 10^{-9} \times 5.4 \times 10^6$
$= 8.1 \times 10^{-3}\ N$

The force is directed along line OA. This is because the negative test charge is repelled by the charge placed at point B but attracted towards point A. Therefore, the force experienced by the test charge is $q = 8.1 \times 10^{-3}\ N$ along OA.

Q 9. Two charges $q_A = 2.5 \times 10^{-7}\ C\ and\ q_B = -2.5 \times 10^{-7}\ C$ are placed at the position A :(0, 0, -15 cn) and B (0, 0, + 15 cm), respectively. Calculate the total charge and dipole moment of the system.

Soln.:

The charges which are located at the given points are shown in the o-ordinate system as:



At point A, total charge amount, $q_A = 2.5 \times 10^{-7}\ C$

At point B, total charge amount, $q_B = -2.5 \times 10^{-7}\ C$

Total charge of the system is, $q_A + q_B = 2.5 \times 10^{-7}\ C - 2.5 \times 10^{-7}\ C = 0$

Distance between two charges at points A and B,

d = 15 + 15 = 30 cm = 0.3 m

Electric dipole moment of the system is given by,

$p = q_A \times d = q_B \times d = 2.5 \times 10^{-7} \times 0.3$ m along positive z – axizs
$= 7.5 \times 10^{-8}\ C$

Therefore, the electric dipole moment of the system is $7.5 \times 10^{-8}\ C$ m along positive z−axis.

Q 10. Calculate the magnitude of the torque acting on the dipole if an electric dipole is aligned at an angle of 30 degree with the direction of a uniform electric field of magnitude $5 \times 10^4\ NC^{-1}$. And the dipole moment of the dipole is $4 \times 10^{-9}\ Cm$

Soln.:

Electric dipole moment, $p = 4 \times 10^{-9}\ Cm$

Angle made by p with a uniform electric field, $\theta = 30^\circ$

Electric field, $E = 5 \times 10^4\ NC^{-1}$

Torque acting on the dipole is given by the relation,

$\tau = pE \sin\theta$
$= 4 \times 10^{-9} \times 5 \times 10^4 \times \sin 30 = 20 \times 10^{-5} \times \frac{1}{2} = 10^{-4}\ Nm$

Therefore, the magnitude of the torque acting on the dipole is $10^{-4}\ Nm$

Q 11. After rubbing a polythene piece with wool, it found that the polythene have a negative charge of $3 \times 10^{-7}\ C$.

(i) Find the total number of electrons which are transferred also find electrons from where electrons are transferred to which material.

(ii) Is there any mass transferred from wool to polythene?

Soln.:

(i) Since the wool is positively charged and the polythene is negatively charged, so we can say that few amount of electrons are transferred from wool to polythene.

Charge on the polythene, q = $3 \times 10^{-7}\ C$.

Amount of charge on an electron, $e = -1.6 \times 10^{-19}\ C$

Let number of electrons transferred from wool to polythene be n

So, by using the given equation we can calculate the value of n,

q = ne

$\Rightarrow n = \frac{q}{e} = \frac{-3 \times 10^{-7}}{-1.6 \times 10^{-19}} = 1.87 \times 10^{12}$

Therefore, the number of electrons transferred from wool to polythene is 1.87×10^{12}

(ii) Yes,

Mass is also transfer as electron is transferred from wool to polythene and an electron particle have some mass.

Mass of an electron, $m_e = 9.1 \times 10^{-3} kg$

Total mass transferred , m = $m_e \times n$

$$= 9.1 \times 10^{-31} \times 1.85 \times 10^{12}$$
$$= 1.706 \times 10^{-18}\ kg$$

Here, the mass transferred is too low that it can be neglected.

Q 12. (i) We are given two insulated copper spheres A and B and they are kept at a distance of 50 cm. The radii of A and B are negligible compared to the distance of separation. What would be the mutual force of electrostatic repulsion, if the spheres are charged with $6.5 \times 10^{-7}\ C$ each?

(ii) If the charge on the spheres is doubled and the distance is halved then calculate the force of repulsion.

Soln.:

(i) Charge on sphere A, $q_A = 6.5 \times 10^{-7}\ C$

Charge on sphere B, $q_B = 6.5 \times 10^{-7}\ C$

Distance between the spheres, r = 50 cm = 0.5 m

Force of repulsion between the two spheres, $F = \frac{1}{4\pi\epsilon_0} \cdot \frac{q_A q_B}{r^2}$

Where ϵ_0 = Permittivity of free space and $\frac{1}{4\pi\epsilon_0} = 9 \times 10^9\ Nm^2C^{-2}$

Therefore,

$$F = \frac{9\times10^9\times(6.5\times10^{-7})^2}{(0.5)^2}$$
$$= 1.52 \times 10^{-2}\ N$$

Therefore, the force between the two spheres is $1.52 \times 10^{-2}\ N$

(ii) After doubling the charge,

Charge on sphere A, $q_A = 1.3 \times 10^{-6}\ C$

Charge on sphere B, $q_B = 1.3 \times 10^{-6}\ C$

The distance between the spheres is halved.

$$\therefore r = \frac{0.5}{2} = 0.25\ m$$

Force of repulsion between the two spheres,

$$F = \frac{1}{4\pi\epsilon_0} \cdot \frac{q_A q_B}{r^2} = \frac{9\times10^9\times1.3\times10^{-6}\times1.3\times10^{-6}}{(0.25)^2}$$
$$= 16 \times 1.52 \times 10^{-2}$$
$$= 0.243\ N$$

Therefore, the force between the two spheres is 0.243 N.

Q 13. Let us assume that the spheres in the previous question are identical in size and also we will bring one more identical sphere but this one will be uncharged and then the first uncharged sphere is brought in contact with the first one and then it is brought in contact with the second and then finally removed. Calculate the new force between A and B?

Soln.:

Distance between the spheres, A and B, r = 0.5 m

Initially, the charge on each of sphere $q = 1.3 \times 10^{-7}\ C$

When the sphere A is touched with An uncharged sphere C, then half of the charge will be transferred to the sphere C. Hence the charge on both the spheres A and C will be q/2.

After that when sphere C with charge q/2 is brought in touch with sphere B with charge q, then charge on each of the sphere will be divided in two equal parts, is.

$$\frac{1}{2}\left(q + \frac{q}{2}\right) = \frac{3q}{4}$$

Hence, charge on each of the spheres, C and B , is $\frac{3q}{4}$

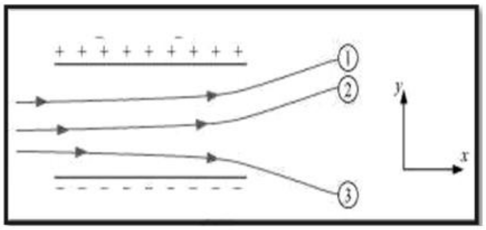
Force of repulsion between sphere A and B is:

$$F = \frac{1}{4\pi\epsilon_0} \cdot \frac{q_A q_B}{r^2} = \frac{1}{4\pi\epsilon_0} \cdot \frac{\frac{q}{2}\times\frac{3q}{4}}{r^2}$$
$$= \frac{1}{4\pi\epsilon_0} \cdot \frac{3q^2}{8r^2}$$
$$= \frac{9\times10^9\times3\times(6.5\times10^{-7})^2}{8\times(0.5)^2} = 5.703 \times 10^{-3}\ N$$

Therefore, the force of attraction between the two spheres is $5.703 \times 10^{-3}\ N$

Therefore, the force of attraction between the two spheres is 5.763 × 10 N

Q 14. In the given figure below, it is showing the path of three particle which are charged and it is travelling in a uniform electrostatic field. Put the appropriate signs for these three charged particles. Which of the above particle will have more charge to mass ratio?



Soln.:

We can see here that the particles 1 and 2 are moving in the direction of the positive charge and we know that the opposite charge attracts each other and the same charge repels each other. So, here we can say that the charge particles 1 and 2 which are going towards the charged particle are negatively charged. And the particle 3 is being attracted towards the negative charge. So, the particle 3 will be the positively charged particle.

The emf or charge to mass ratio is directly proportional to the amount of depletion or depletion at a given velocity. Here we can see that the particle 3 is depleting more as compared to the other two. Therefore, it will have higher charge to mass ratio.

Question 1.15 :

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 y z – plane?

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

Answer 1.15 :

(a) Electric field intensity, $E = 3 \times 10^3\ \hat{i}$ N / C

Magnitude of electric field intensity, $|E| = 3 \times 10^3$ N / C

Side of the square, s = 10 cm = 0.1 m

Area of the square, $A = s^2 = 0.01\ m^2$

The plane of the square is parallel to the y – z plane. Hence, angle between the unit vector normal to the plane and electric field, $\theta = 0°$

Flux (φ) through the plane is given by the relation,

$\varphi = |E| A \cos\theta$

$\varphi = 3 \times 10^3 \times 0.01 \times \cos 0°$

$\varphi = 30\ N\ m^2/C$

(b) Plane makes an angle of 60 ° with the x – axis.

Hence, $\theta = 60°$

Flux, $\varphi = |E| A \cos\theta$

Flux, $\varphi = 3 \times 10^3 \times 0.01 \times \cos 60°$

Flux, $\varphi = 30 \times 0.5$

Flux, $\varphi = 15\ N\ m^2/C$

Question 1.16 :

What is the net flux of the uniform electric field of Question 1.15 through a cube of side 20 cm oriented so that its faces are parallel to the coordinate planes ?

Answer 1.16 :

All the faces of a cube are parallel to the coordinate axes. Therefore, the number of field lines entering the cube is equal to the number of field lines piercing out of the cube. As a result, net flux through the cube is zero.

Question 1.17 :

Careful measurement of the electric field at the surface of a black box indicates that the net outward flux through the surface of the box is $8.0 \times 10^3\ N\ m^2/C$.

(a) What is the net charge inside the box ?

(b) If the net outward flux through the surface of the box were zero, could you conclude that there were no charges inside the box ? Why or Why not ?

Answer 1.17 :

(a) Net outward flux through the surface of the box, φ = 8.0 × 10 ^{3} N m ^{2} /C

For a body containing net charge q, flux is given by the relation,

$\phi = \frac{q}{\varepsilon_0}$ $\varepsilon_0 = permitivityoffreespace$ $\varepsilon_0 = 8.854 \times 10^{-12} N^{-1} C^2 m^{-2}$ $q = \varepsilon_0 \phi$

= 8.854 x 10 $^{-12}$ x 8.0 x 10 ^{3} C = 7.08 x 10 $^{-8}$ C = 0.07 μC

Thus, the total charge inside the box is 0.07 μC

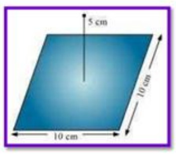
(b) No

Net flux piercing out through a body depends on the net charge contained in the body. If net flux is zero, then it can be inferred that net charge inside the body is zero. The body may have equal amount of positive and negative charges.

Question 1.18 :

A point charge + 10 μC is at a distance 5 cm directly above the centre of a square of side 10 cm, as shown in Fig. 1.34. What is the magnitude of the electric flux through the square?

(Hint : Think of the square as one face of a cube with edge 10 cm)



Answer 1.18 :

The square can be considered as one face of a cube of edge 10 cm with a centre where charge q is placed. According to Gauss's theorem for a cube, total electric flux is through all its six faces.

$\phi_{Total} = \frac{q}{\epsilon_0}$

Hence, electric flux through one face of the cube i.e., through the square is

$\phi = \frac{\phi_{Total}}{6} = \frac{1}{6} \cdot \frac{q}{\epsilon_0}$

Here,

ϵ_0 = permittivity of free space = 8.854 x 10 $^{-12}$ n $^{-1}$ c ^{2} m $^{-2}$

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

Therefore,

$\phi = \frac{1}{6} \cdot \frac{10 \times 10^{-6}}{8.854 \times 10^{-12}}$

ϕ = 1.88 x 10 ^{5} N m ^{2} C $^{-1}$

Therefore, electric flux through the square is 1.88 × 10 ^{5} N m ^{2} C $^{-1}$

Question 1.19 :

A point charge of 2.0 μC is at the centre of a cubic Gaussian surface 9.0 cm on edge. What is the net electric flux through the surface ?

Answer 1.19 :

Net electric flux (φ_{Net}) through the cubic surface is given by

$\phi_{net} = \frac{q}{\epsilon_0}$

Here,

ϵ_0 = permittivity of free space = 8.854 × 10 $^{-12}$ n $^{-1}$ c ^{2} m $^{-2}$

$q = total\ charge\ contained\ in\ the\ cube\ given\ = 2.0 \mu\ C\ = 2 \times 10^{-6} C$

Therefore,

$\phi_{net} = \frac{2 \times 10^{-6}}{8.854 \times 10^{-12}}$ $\phi_{net} = 2.26 \times 10^5 Nm^2 C^{-1}$

The total electric flux through the surface of the cube given is , $\phi_{net} = 2.26 \times 10^5 Nm^2 C^{-1}$

Question 1.20 :

A point charge causes an electric flux of – 1.0 × 10^3 N m^2 /C to pass through a spherical Gaussian surface of 10.0 cm radius centered on the charge.

(a) If the radius of the Gaussian surface were doubled, how much flux would pass through the surface ?

(b) What is the value of the point charge ?

Answer 1.20 :

(a) Electric flux, Φ = – 1.0 × 10^3 N m^2 /C

Radius of the Gaussian surface, r = 10.0 cm

Electric flux piercing out through a surface depends on the net charge enclosed inside a body. It does not depend on the size of the body. If the radius of the Gaussian surface is doubled, then the flux passing through the surface remains the same i.e., – 10^3 N m^2 /C.

(b) Electric flux is given by the relation

$\phi_{Total} = \frac{q}{\epsilon_0}$

Here,

ϵ_0 = permittivity of free space = 8.854 x 10^{-12} n^{-1} c^2 m^{-2}

q = total charge contained enclosed by the spherical surface = φ ε_0

q = – 1.0 x 10^3 x 8.854 x 10^{-12}

q = – 8.854 x 10^{-9} C

q = – 8.854 n C

Therefore, the value of the point charge is – 8.854 n C.

Question 1.21 :

A conducting sphere of radius 10 cm has an unknown charge. If the electric field 20 cm from the centre of the sphere is 1.5 × 10^3 N/C and points radially inward, what is the net charge on the sphere?

Answer 1.21 :

Electric field intensity (E) at a distance (d) from the centre of a sphere containing net charge q is given by the relation,

$E = \frac{1}{4\pi\epsilon_0} \cdot \frac{q}{d^2}$

Where, q = Net charge = 1.5 × 10^3 N/C

d = Distance from the centre = 20 cm = 0.2 m

ε_0 = Permittivity of free space and $\frac{1}{4\pi\epsilon_0} = 9 \times 10^9 Nm^2C^{-2}$

Therefore, the net charge on the sphere is 6.67 n C.

Question 1.22 :

A uniformly charged conducting sphere of 2.4 m diameter has a surface charge density of 80.0 μC /m^2

(a) Find the charge on the sphere.

(b) What is the total electric flux leaving the surface of the sphere?

Answer 1.22 :

(a) Diameter of the sphere, d = 2.4 m

Radius of the sphere, r = 1.2 m

Surface charge density, σ = 80.0 μC /m^2 = 80 × 10^{-6} C/m^2

Total charge on the surface of the sphere,

Q = Charge density × Surface area

= σ × 4πr^2

= 80 × 10^{-6} × 4 × 3.14 × $(1.2)^2$

= 1.447 × 10^{-3} C

Therefore, the charge on the sphere is 1.447 × 10^{-3} C.

(b) Total electric flux (φ_{Total}) leaving out the surface of a sphere containing net charge Q is given by the relation,

$\phi_{Total} = \frac{q}{\epsilon_0}$

Here,

ϵ_0 = permittivity of free space = 8.854 x 10^{-12} n^{-1} c^2 m^{-2}

Q = 1.63 x 10^8 N C^{-1} m^2

Therefore, the total electric flux leaving the surface of the sphere is 1.63 × 10^8 N C^{-1} m^2

Question 1.23 :

An infinite line charge produces a field of 9 × 10^4 N/C at a distance of 2 cm. Calculate the linear charge density.

Answer 1.23 :

Electric field produced by the infinite line charges at a distance d having linear charge density λ is given by the relation,

$E = \frac{\lambda}{2\pi\epsilon_0 d}$

à $\lambda = 2\pi\epsilon_0 dE$

Here,

d = 2 cm = 0.02 m

E = 9 x 10^4 N / C

ε_0 = Permittivity of free space and $\frac{1}{4\pi\epsilon_0} = 9 \times 10^9 Nm^2C^{-2}$

Question 1.24 :

Two large, thin metal plates are parallel and close to each other. On their inner faces, the plates have surface charge densities of opposite signs and of magnitude 17.0 × 10^{-22} C /m^2

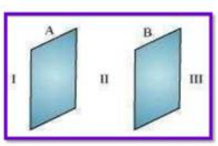
What is E :

(a) In the outer region of the first plate,

(b) In the outer region of the second plate, and (c) between the plates ?

Answer 1.24 :

The situation is represented in the following figure.



A and B are two parallel plates close to each other. Outer region of plate A is labeled as I, outer region of plate B is labeled as III, and the region between the plates, A and B, is labeled as II.

Charge density of plate A, σ = 17.0 × 10^{-22} C/m^2

Charge density of plate B, σ = – 17.0 × 10^{-22} C/m^2

In the regions, I and III, electric field E is zero. This is because charge is not enclosed by the respective plates.

Electric field E in region II is given by the relation,

$E = \frac{\sigma}{\epsilon_0}$

here,

ε_0 = Permittivity of free space = 8.854 × 10^{-12} $N^{-1}C^2$ m^{-2}

$E = \frac{17.0 \times 10^{-22}}{8.854 \times 10^{-12}}$ = 1.92 x 10^{-10} N/C

Therefore, electric field between the plates is 1.92 x 10^{-10} N/C