NCERT Solutions for Class-XII Physics

Chapter-1

NCERT Physics Class 12

1. What is the force between two small charged spheres having charges of 2×10^{-7} C and 3×10^{-7} C placed 30 cm apart in air?

1. Repulsive force of magnitude 6×10^{-3} N
Charge on the first sphere, $q_1 = 2 \times 10^{-7}$ C
Charge on the second sphere, $q_2 = 3 \times 10^{-7}$ C
Distance between the spheres, r = 30 cm = 0.3 m

Electrostatic force between the spheres is given by the relation $F = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q_1 q_2}{r^2}$

Where, ε_0 = Permittivity of free space and $\frac{1}{4\pi\varepsilon_0} = 9 \times 10^9 \text{ Nm}^2\text{C}^{-2}$

Therefore, force

$$F = \frac{9 \times 10^9 \times 2 \times 10^{-7}}{(0.3)^2} = 6 \times 10^{-3} \text{ N}$$

Hence, force between the two small charged spheres is 6×10^{-3} N. The charges are of same nature. Hence, force between them will be repulsive.

2. The electrostatic force on a small sphere of charge 0.4 μC due to another small sphere of charge – 0.8 μC in air is 0.2 N.
(a) What is the distance between the two spheres?
(b) What is the force on the second sphere due to the first?

2. (a) The electrostatic force, F = 0.2 N
Charge on this present sphere, $q_1 = 0.4\ \mu C = 0.4 \times 10^{-6}$ C
Charge on the other sphere, $q_2 = -0.8\ \mu C = -0.8 \times 10^{-6}$ C
The electrostatic force between the spheres can be given by the equation,

$$F = \frac{1}{4\pi \epsilon_0} \frac{q_1 q_2}{r^2} \quad ...(1)$$

Where, q_1 and q_2 are the charges.
r is the distance between the charges.

$\frac{1}{4\pi \epsilon_0}$ is a constant and its value is 9×10^9 N m^2 C^{-2}

ϵ_0 is the permittivity of free space. Its value is 8.85×10^{-12} (F/m)
Therefore, from equation (1),

$$r^2 = \frac{q_1 \times q_2}{4 \times \pi \times \in_0 \times F}$$

$$\Rightarrow r^2 = \frac{0.4 \times 10^{-6} C \times -0.8 \times 10^{-6} C \times 9 \times 10^9 N\,m^2\,C^{-2}}{0.2\,N}$$

$\Rightarrow r^2 = 144 \times 10^{-4}\ m^2$

Taking square root both the sides,

$\Rightarrow r = \sqrt{144 \times 10^{-4}}$

r = 0.12 m

Hence, the distance between the two spheres is 0.12 m.

(b) Since the nature of the charges on the spheres is opposite, the force between them will be attractive in nature. The spheres will attract each other with the same amount of force. Therefore, the force on the second sphere due to the first sphere will be 0.2 N.

3. Check that the ratio $ke^2/G\,m_e\,m_p$ is dimensionless. Look up a Table of Physical Constants and determine the value of this ratio. What does the ratio signify?

3. The given ratio is $\frac{ke^2}{Gm_e m_p}$. Where G = Gravitational constant. Its unit is N m^2 kg^{-2} m_e and m_p = Masses of electron and proton and their unit is kg.

e = Electric charge. Its unit is C.

$k = \frac{1}{4\pi\varepsilon_0}$ and its unit is N m^2C^{-2}.

Therefore, unit of the given ratio

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

Hence, the given ratio is dimensionless.

$e = 1.6 \times 10^{-19}$ C

$G = 6.67 \times 10^{-11}$ N m^2 kg^{-2}

$m_e = 9.1 \times 10^{-31}$ kg

$m_p = 1.66 \times 10^{-27}$ kg

Hence, the numerical value of the given ratio is

$$\frac{ke^2}{Gm_e m_p} = \frac{9 \times 10^9 \times \left(1.6 \times 10^{-19}\right)^2}{6.67 \times 10^{-11} \times 9.1 \times 10^{-31} \times 1.67 \times 10^{-27}} \approx 2.3 \times 10^{39}$$

This is the ratio of electric force to the gravitational force between a proton and an electron, keeping distance between them constant.

4. (a) Explain the meaning of the statement 'electric charge of a body is quantised'.

(b) Why can one ignore quantisation of electric charge when dealing with macroscopic i.e., large scale charges?

4. (a) Electric charge of a body is quantised.

This statement means that charge on a body can take only integral values i.e. (1, 2, 3, 4, …. N) number of electrons can be transferred from one body to another. The charges cannot be transferred in fractions. It can only be an integral multiple of the charge of one electron.

Therefore, as a result, a body will possess a charge that is an integral multiple of the electric charge of an electron.

(b) When considered on a macroscopic level or a large scale, we tend to ignore the quantisation of electric charges. This is because on a large scale, the charges that we deal with are extremely huge when compared to the magnitude of an individual charge. Hence, we can say that the quantisation of electric charge is not useful on a macroscopic scale. It is therefore ignored and considered to be of continuous nature.

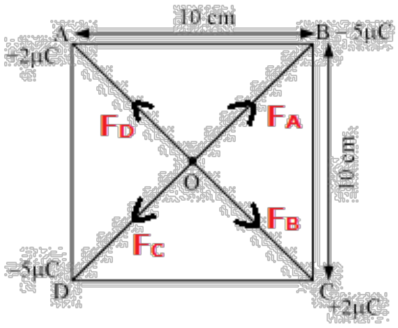
5. When a glass rod is rubbed with a silk cloth, charges appear on both. A similar phenomenon is observed with many other pairs of bodies. Explain how this observation is consistent with the law of conservation of charge.

5. Rubbing produces charges of equal magnitude but of opposite nature on the two bodies because charges are created in pairs. This phenomenon of charging is called charging by friction. The net charge on the system of two rubbed bodies is zero. This is because equal amount of opposite charges annihilate each other. When a glass rod is rubbed with a silk cloth, opposite natured charges appear on both the bodies. This phenomenon is in consistence with the law of conservation of energy. A similar phenomenon is observed with many other pairs of bodies.

6. Four point charges $q_A = 2\ \mu C$, $q_B = -5\ \mu C$, $q_C = 2\ \mu C$, and $q_D = -5\ \mu C$ are located at the corners of a square ABCD of side 10 cm. What is the force on a charge of $1\ \mu C$ placed at the centre of the square?

6. Consider a square of side 10 cm. Four charges are placed in its corners. Let O be the centre of the square.

The diagram is:



AB = BC = CD = DA = 10 cm

Diagonal of a square = $\sqrt{2}$ × Side of a square

Therefore,

AC = BD = 10$\sqrt{2}$ cm

AO = OC = DO = OB = (10$\sqrt{2}$)/2 cm = 5$\sqrt{2}$ cm

(i) A charge of magnitude 1μC is placed at O, the centre of the square.

Corner A has a positive charge. The force of repulsion between the charge at A and the charge at the centre, O, will be equal in magnitude and opposite in direction when compared to the force of repulsion between the charge placed at C and charge placed at O. Hence, these two forces will cancel each other.

(ii) On a similar note, the force of attraction between the charge kept at D and charge kept at O will be equal in magnitude but opposite in direction to the force of attraction between the charge kept at B and the charge kept at O. These two will also cancel each other.

Therefore, we can conclude that the resultant force by the four charges kept in the corners on the charge that is kept in the centre will be zero.

7. (a) An electrostatic field line is a continuous curve. That is, a field line cannot have sudden breaks. Why not?

(b) Explain why two field lines never cross each other at any point?

7. (a) An electrostatic field line is a continuous curve because a charge experiences a continuous force when traced in an electrostatic field. The field line cannot have sudden breaks because the charge moves continuously and does not jump from one point to the other.

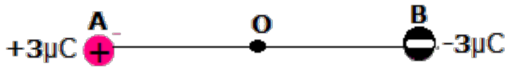
(b) If two field lines cross each other at a point, then electric field intensity will show two directions at that point. This is not possible. Hence, two field lines never cross each other.

8. Two point charges q_A = 3 μC and q_B = –3 μC are located 20 cm apart in vacuum.

(a) What is the electric field at the midpoint O of the line AB joining the two charges?

(b) If a negative test charge of magnitude 1.5×10^{-9} C is placed at this point, what is the force experienced by the test charge?

8. (a) The diagram is shown as below:



AB = 20 cm

∵ O is the midpoint of the line AB.

∴ AO = OB = 10 cm = 0.1 m

Let the Net electric field at the point O = E

The electric field at a point caused by charge q, is given as,

$$E = \frac{1}{4\pi \epsilon_0} \frac{q}{r^2} \quad ....(1)$$

Where, q is the charge,

r is the distance between the charge and the point at which the field is being calculated

$\frac{1}{4\pi \epsilon_0}$ is a constant and its value is 9×10^9 N m^2 C^{-2}

ϵ_0 is the permittivity of free space. Its value is 8.85×10^{-12} (F/m)

∴ The electric field at the point O caused by q_A = 3 μC

$$E_A = \frac{3 \times 10^{-6} C}{4\pi \epsilon_0 \times (0.1m)^2}$$

$$\Rightarrow E_A = \frac{9 \times 10^9 N\, m^2 C^{-2} \times 3 \times 10^{-6} C}{\times (0.1m)^2}$$

The direction of E_A will be along OB.

Also, the electric field at O caused by q_B = –3 μC

$$E_B = \frac{-3 \times 10^{-6} C}{4\pi \epsilon_0 \times (0.1m)^2}$$

$$\Rightarrow E_B = \frac{9 \times 10^9 N\, m^2 C^{-2} \times 3 \times 10^{-6} C}{\times (0.1m)^2}$$

The direction of E_B will be along OB.

Note: Both the field are acting in the same direction along OB, this is because the charges are of opposite nature, ∴ the force will be attractive.

Hence, we can sum them up to find the resultant electric field.

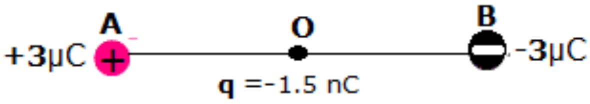
$E_{net} = E_A + E_B$

$\Rightarrow E_{net} = 2E_A$

$$\Rightarrow E_{net} = 2 \times \frac{9 \times 10^9 N\, m^2 C^{-2} \times -3 \times 10^{-6} C}{\times (0.1m)^2}$$

∴ $E_{net} = 5.4 \times 10^4$ N/C (along OB)

(b) The diagram is:



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

The force that is experienced by q when placed at O, F.

$F_O = q \times E_{Net}$

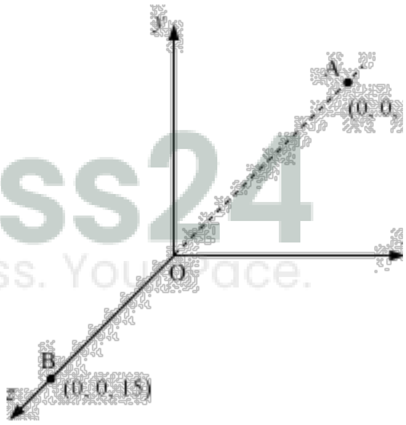
Where E is the Electric field at the point O.

$\therefore$ F = 1.5×10^{-9} C $\times$ 5.4×10^4 N/C

$\Rightarrow$ F = $8.1 \text{ x } 10^{-3}$ N

The negative test charge will be repelled by the force placed at B and attracted by the force placed at A. Therefore, this force will be in the direction of OA.

9. A system has two charges $q_A = 2.5 \times 10^{-7}$ C and $q_B = -2.5 \times 10^{-7}$ C located at points A: (0, 0, – 15 cm) and B: (0, 0, + 15 cm), respectively. What are the total charge and electric dipole moment of the system?



9. Both the charges can be located in a coordinate frame of reference as shown in the given figure.

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

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

Total charge of the system, $q = q_A + q_B = 2.5 \times 10^7$ 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,

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

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

10. An electric dipole with dipole moment 4×10^{-9} C m is aligned at 30° with the direction of a uniform electric field of magnitude 5×10^4 N C^{-1}. Calculate the magnitude of the torque acting on the dipole.

10. The electric dipole moment can be defined as the measure of the separation of positive as well as negative charges within a specific system. It tells us about the given system's overall polarity.

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

Angle between p and uniform electric field, $\theta = 30°$

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

The torque acting on a dipole is given by:
T = p × E
T = pE sinθ
= 4×10^{-9} C m × 5×10^{4} NC^{-1} × (0.5)
= 10^{-4} Nm
The magnitude of torque acting on the given dipole is 10^{-4} Nm.

11. A polythene piece rubbed with wool is found to have a negative charge of 3×10^{-7} C.
(a) Estimate the number of electrons transferred (from which to which?)
(b) Is there a transfer of mass from wool to polythene?

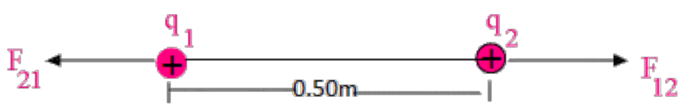
11. (a) When polythene is rubbed against wool, a number of electrons get transferred from wool to polythene. Hence, wool becomes positively charged and polythene becomes negatively charged.
Amount of charge on the polythene piece, q = -3×10^{-7} C
Amount of charge on an electron, e = -1.6×10^{-19} C Number of electrons transferred from wool to polythene = n
n can be calculated using the relation, q = ne

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

Therefore, the number of electrons transferred wool to polythene is 1.87×10^{12}.
(b) Yes.
There is a transfer of mass taking place. This is because an electron has mass, $m_e = 9.1 \times 10^{-3}$ kg
Total mass transferred to polythene from wool, m = $m_e \times n$
= $9.1 \times 10^{-31} \times 1.85 \times 10^{12}$
= 1.706×10^{-18} kg
Hence, a negligible amount of mass is transferred from wool to polythene.

12. (a) Two insulated charged copper spheres A and B have their centers separated by a distance of 50 cm. What is the mutual force of electrostatic repulsion if the charge on each is 6.5×10^{-7} C? The radii of A and B are negligible compared to the distance of separation.
(b) What is the force of repulsion if each sphere is charged double the above amount, and the distance between them is halved?

12. Distance between centres of spheres, r = 50 cm = .5 m
Charge on each sphere, q = 6.5×10^{-7} C



(a) Mutual force of electrostatic repulsion

$$F = \frac{1}{4\pi\epsilon_0} \times \frac{q_1 q_2}{r^2} \qquad ....(1)$$

Where, F = mutual force of attraction

q_1 = charge on sphere 1

q_2 = charge on sphere 2

r = distance between centres

$$\frac{1}{4\pi\epsilon_0} = 10^9\, Nm^2C^{-2}$$

Where, ε_0 is the permittivity of the free space.

Now, putting the values of q_1, q_2 and r in equation (1).

$$F = 9 \times 10^9\, Nm^2C^{-2} \times \frac{\left(6.5 \times 10^{-7} C\right)^2}{(0.5m)^2}$$

$\Rightarrow$ F = 1.52 × 10^{-2} N

Hence the mutual force between two spheres is 1.52 × 10^{-2} N. Since the sign is positive so the force is repulsive in nature.

(b) Force if charges on each sphere is doubled and the distance is halved.

Given:

$Q_1 = 2 \times q$

$Q_2 = 2 \times q$

$R = 0.5 \times r$

Using Coulomb's law, we get,

$$F = \frac{1}{4\pi\epsilon_0} \times \frac{q_1 q_2}{r^2} \qquad ...(1)$$

where, $\frac{1}{4\pi\epsilon_0} = 10^9\, Nm^2C^{-2}$

Where, ε_0 is the permittivity of the free space.

$$\Rightarrow F = 9 \times 10^9 \times \frac{(2q)^2}{(0.5 \times r)^2}$$

$$\Rightarrow F = 9 \times 10^9\, Nm^2C^{-2} \times 16 \times \frac{\left(6.5 \times 10^{-7} C\right)^2}{(0.5m)^2}$$

$\Rightarrow$ F = 0.243 N

The mutual force is 0.243N and it is repulsive in nature.

The new force is found to be 16 times the force in case I.

13. Suppose the spheres A and B in Exercise 1.12 have identical sizes. A third sphere of the same size but uncharged is brought in contact with the first, then brought in contact with the second, and finally removed from both. What is the new force of repulsion between A and B?

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

Initially, the charge on each sphere, $q = 6.5 \times 10^{-7}$ C

When sphere A is touched with an uncharged sphere C, q/2 amount of charge from A will transfer to sphere C. Hence, charge on each of the spheres, A and C, is q/2.

When sphere C with charge q/2 is brought in contact with sphere B with charge q, total charges on the system will divide into two equal halves given as,

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

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

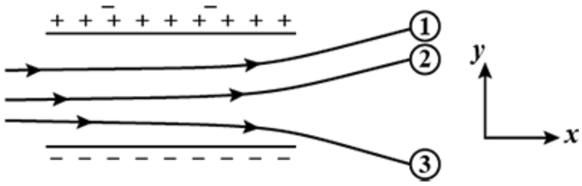
Force of repulsion between sphere A having charge q/2 and sphere B having charge $\frac{3q}{4}$ is

$$F=\frac{1}{4\pi\varepsilon_0}\cdot\frac{q_A q_B}{r^2}=\frac{1}{4\pi\varepsilon_0}\cdot\frac{\frac{q}{2}\times\frac{3q}{4}}{r^2}$$

$$=\frac{1}{4\pi\varepsilon_0}\cdot\frac{3q^2}{8r^2}=\frac{9\times10^9\times3\times\left(6.5\times10^{-7}\right)^2}{8\times(0.5)^2}=5.703\times10^{-3}\,\text{N}$$

Therefore, the force of attraction between the two spheres is 5.703×10^{-3} N.

14. Figure shows tracks of three charged particles in a uniform electrostatic field. Give the signs of the three charges. Which particle has the highest charge to mass ratio?



14. 1. Particles 1 and 2 are deflected towards the positively charged plate, hence it can be concluded that particles 1 and 2 are negatively charged.

2. Particle 3 is deflected towards the negatively charged plate hence it is positively charged.

The deflection of a particle is proportional to the charge to mass ratio (q : m) of the particle. We observe that particle 3 has maximum deflection, so it has the highest charge to mass ratio.

Explanation: Force on a particle in electric field

$F = q \times E$ … (1)

Where, q = charge on particle

E = magnitude of electric field

$m \times a = q \times E$ … (2)

Where m = mass of particle

a = acceleration of particle

From equation (2)

$$\Rightarrow a = \frac{q \times E}{m}$$

The electric field in the given case is constant, hence we can write.

$$\Rightarrow a \propto \frac{q}{m} \quad ...(3)$$

From the equation (3) we can conclude that acceleration of a charge particle with charge q and mass m in uniform electric field is proportional to the charge to mass ratio of the particle.

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 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?

15. 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, θ = 0°

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

$\phi = |E|A \cos\theta = 3 \times 10^3 \times 0.01 \times \cos 0° = 30\ N\ m^2/C$

(b) Plane makes an angle of 60° with the x-axis. Hence, θ = 60°

Flux, $\phi = |E|A\cos\theta = 3 \times 10^3 \times 0.01 \times \cos 60°$

$$= 30 \times \frac{1}{2} = 15\ N\ m^2/C$$

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

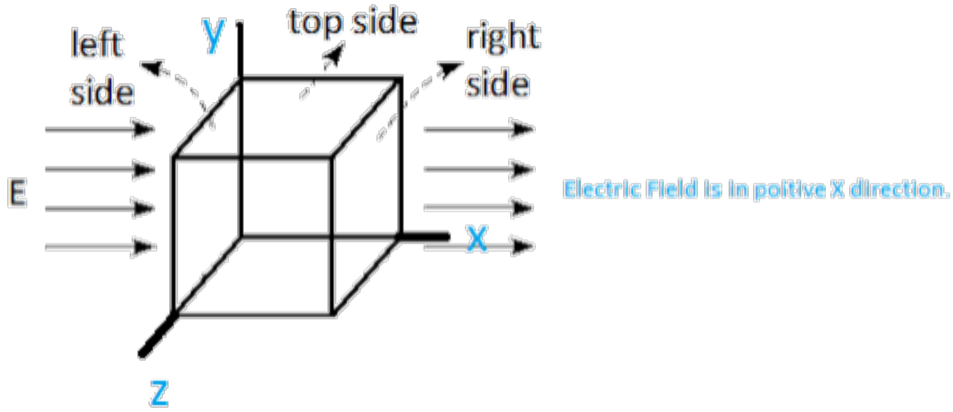
16. Flux, $Ø = q/\varepsilon_0$

Where, q = net charged enclosed

ε_0 = permittivity of free space

$\varepsilon_0 = 8.85\times 10^{-12}\ N^{-1}\ m^{-2}C^2$

Since no charge is enclosed by the cube, i.e., q = 0, the net flux through the Cube is zero.



Note: The number of field lines entering the cube is equal to the number of field lines leaving the cube. Hence the net flux becomes zero.

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?

17. (a) Net outward flux through the surface of the box, $\phi = 8.0 \times 10^3\ N\ m^2/C$

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

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

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

$q = \varepsilon_0\phi$

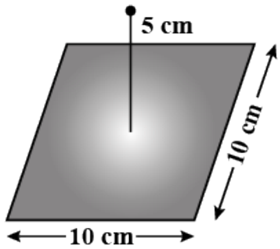
$= 8.854 \times 10^{-12} \times 8.0 \times 10^3\ C = 7.08 \times 10^{-8}\ C = 0.07\ \mu C$

Therefore, the net 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.

18. A point charge +10 μC is 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)



18. Given:

$q = +10\ \mu C$

$s = 10$ cm

Assume the charge to be enclosed by a cube, where the square is one of its sides.

Now, let us find the total flux through the imaginary cube.

We know that,

Flux, $\varnothing = q/\varepsilon$ … (1)

Where, q = net charged enclosed

ε_0 = permittivity of free space

$\varepsilon_0 = 8.85\times 10^{-12}\ N^{-1}\ m^{-2}C^2$

Now plugging the values of q and ε_0 in equation (2)

$$\varnothing = \frac{10^{-6}\ C}{8.85 \times 10^{-12} N^{-1} m^2 C^2}$$

$\Rightarrow \varnothing = 11.28 \times 10^5\ Nm^{-2}\ C^{-1}$

We understand that flux through all the faces of cube will be equal;

Let flux through the square $= \varnothing_a$

Hence,

$\varnothing_a = \varnothing/6$

Explanation: The net flux will be distributed equally among all 6 faces of the cube. Hence, the square will have one sixth of the total flux.

$\varnothing_a = 1.88\ Nm^{-2}C^{-1}$

The flux through the square is $1.88 \times 10^5\ Nm^2\ C^{-1}$.

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?

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

$$\phi_{Net} = \frac{q}{\varepsilon_0}$$

Where,

ε_0 = Permittivity of free space

$= 8.854 \times 10^{-12}\ N^{-1}\ C^2\ m^{-2}$

q = Net charge contained inside the cube

$= 2.0\ \mu C = 2 \times 10^{-6}$ C

$$\therefore \phi_{Net} = \frac{2\times10^{-6}}{8.854\times10^{-12}}$$

$= 2.26 \times 10^5$ N m^2 C^{-1}

The net electric flux through the surface is 2.26×10^5 N m^2C^{-1}.

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

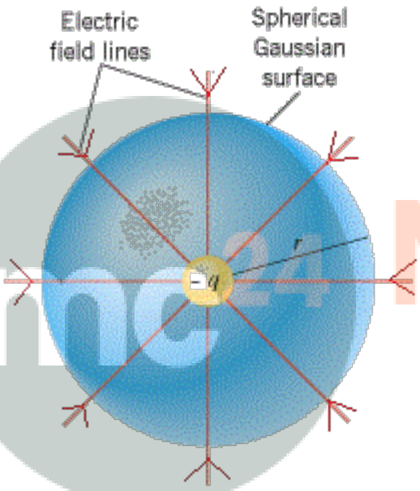
(a) If the radius of the Gaussian surface were doubled, how much flux would pass through the surface?

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

20. Given:

$Ø = -1.0 \times 10^3$ Nm^2C^{-1}

$r_1 = 10.0$ cm



(a) Flux if the radius of the Gaussian surface is doubled.

If the radius is doubled then the flux would remain same i.e., -1.0×10^3 Nm^2 C^{-1}.

The geometry of the Gaussian surface doesn't affect the total flux through it. The net charge enclosed by Gaussian surface determines the net flux.

(b) Let value of point charge enclosed by Gaussian surface = q

We know that,

Flux, $Ø = q/\varepsilon_0$ … (1)

Where, q = net charged enclosed

ε_0 = permittivity of free space

$\varepsilon_0 = 8.85\times 10^{-12}$ N^{-1} $m^{-2}C^2$

Now plugging, the values Ø and ε_0 in equation (1).

$q = Ø \times \varepsilon_0$

$\Rightarrow q = -1.0 \times 10^3$ Nm^2 $C^{-1} \times 8.85 \times 10^{-12}N^{-1}m^{-2}C^2$

$\Rightarrow q = -8.85 \times 10^{-9}$ C

The charge enclosed by the surface is -8.85×10^{-9} C.

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?

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

$$E = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q}{d^2}$$

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 $\frac{1}{4\pi\varepsilon_0} = 9 \times 10^9\ \mathrm{Nm^2C^{-2}}$

Therefore,

$$q = E(4\pi\varepsilon_0)d^2 = \frac{1.5 \times 10^3}{9 \times 10^9}$$

= 6.67×10^9 C = 6.67 nC

Therefore, the net charge on the sphere is 6.67 nC.

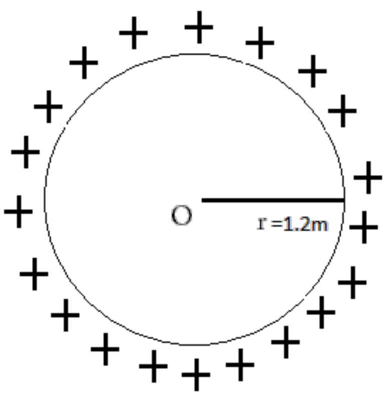
22. A uniformly charged conducting sphere of 2.4 m diameter has a surface charge density of 80.0 $\mu C/m^2$.

(a) Find the charge on the sphere.

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

22. **Given:** radius of sphere, r = 1.2 m

Surface charge density, σ = 80.0 $\mu C/m^2$



(a) Let charge on sphere = q

We understand that,

Total charge, Q = Surface charge density × surface area.

Surface area of sphere, $S = 4\pi r^2$

$S = 18.08\ m^2$

$Q = 80 \times 10^{-6}\ cm^{-2} \times 18.08\ m^{-2}$

$\Rightarrow Q = 1.447 \times 10^{-3}\ C$

(b) Let total electric flux leaving the surface of sphere = $\emptyset$

We know that,

Flux, $\emptyset = q/\varepsilon_0$ … (1)

Where, Q = net charged.

ε_0 = permittivity of free space

$\varepsilon_0 = 8.85 \times 10^{-12}\ N^{-1}\ m^{-2}C^2$

By, plugging the values of q and ε_0 in equation (1), we get,

$$\Rightarrow \emptyset = \frac{1.447\times10^{-3}C}{8.85\times10^{-12}N^{-1}C^2m^{-2}}$$

$\Rightarrow \emptyset = 1.63\times 10^8\ Nm^2C^{-1}$

The total flux through the sphere is $1.63 \times 10^8\ Nm^2C^{-1}$.

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.

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

$$E = \frac{\lambda}{2\pi\varepsilon_0 d} \Rightarrow \lambda = 2\pi\varepsilon_0 dE$$

Where, d = 2 cm = 0.02 m, $E = 9 \times 10^4$ N/C

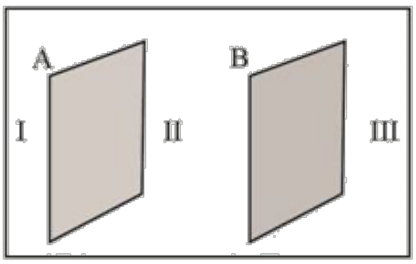
ε_0 = Permittivity of free space and $\frac{1}{4\pi\varepsilon_0} = 9\times10^9\ Nm^2C^{-2}$

Therefore,

$$\lambda = \frac{0.02\times9\times10^4}{2\times9\times10^9} = 10\ \mu C/m$$

Therefore, the linear charge density is 10 μC/m.

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:



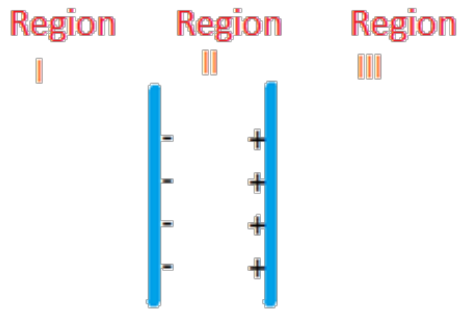
(a) in the outer region of the first plate,
(b) in the outer region of the second plate, and
(c) between the plates?

24. Given:

Surface charge density on plate A, $\sigma_A = -17.0 \times 10^{-22}$ cm^{-2}

Surface charge density on plate B, $\sigma_B = 17.0 \times 10^{-22}$ cm^{-2}

The arrangement of plates are as show:



Let electric field in region 1 = E_1

region 2 = E_2

region 3 = E_3

The electric field in region I and region III is zero because no charge is present in these regions.

$E_1 = 0$

$E_2 = 0$

We know that,

$E_3 = \sigma/\varepsilon_0$ ... (1)

where, σ = Surface charge density

ε_0 = permittivity of free space

$\varepsilon_0 = 8.85 \times 10^{-12}\ N^{-1}\ m^{-2}C^2$

Now, plugging the Values in equation (1).

$$\Rightarrow E_3 = \frac{17 \times 10^{-22}\, Cm^{-2}}{8.85 \times 10^{-12}\, N^{-1}m^{-2}C^2}$$

$\Rightarrow E_3 = 1.92 \times 10^{-10}\ NC^{-1}$

The electric field in the region enclosed by the plates is found to be $1.92 \times 10^{-10}\ NC^{-1}$.

The electric field in region III is $1.92 \times 10^{-10}\ NC^{-1}$.