QB365 Question Bank Software Study Materials

Electrostatics Important 2 Marks Questions With Answers (Book Back and Creative)

12th Standard

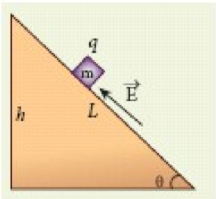
Physics

Total Marks : 40

2 Marks

20 x 2 = 40

1) A block of mass m carrying a positive charge q is placed on an insulated frictionless inclined plane as shown in the figure. A uniform electric field E is applied parallel to the inclined surface such that the block is at rest. Calculate the magnitude of the electric field E.

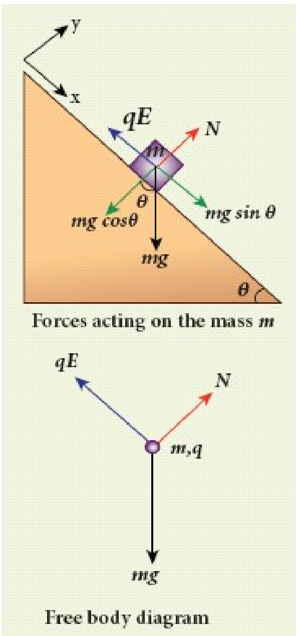


Answer : Note: A similar problem is solved in XIth Physics volume I, unit 3 section 3.3.2. There are three forces that acts on the mass m:

(i) The downward gravitational force exerted by the Earth (mg)

(ii) The normal force exerted by the inclined surface (N)

(iii) The Coulomb force given by uniform electric field (qE) The free body diagram for the mass m is drawn below.



A convenient inertial coordinate system is located in the inclined surface as shown in the figure. The mass m has zero net acceleration both in x and y-direction.

Along x-direction, applying Newton's second law, we have

mg sinθ$\hat{i}$ - qE$\hat{i}$ = 0

mg sinθ - q E = 0

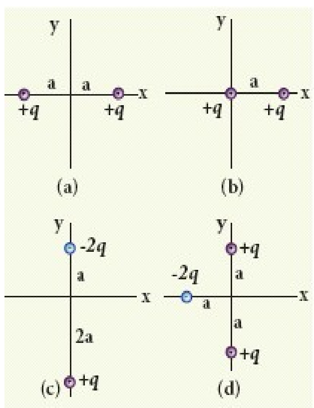
or, E = $\frac{mgsin\theta}{q}$

Note that the magnitude of the electric field is directly proportional to the mass m and inversely proportional to the charge q. It implies that, if the mass is increased by keeping the charge constant, then a strong electric field is required to stop the object from sliding. If the charge is increased by keeping the mass constant, then a weak electric field is sufficient to stop the mass from sliding down the plane.

The electric field also can be expressed in terms of height and the length of the inclined surface of the plane.

E = $\frac{mgh}{qL}$.

2) Calculate the electric dipole moment for the following charge configurations.



Answer : **Case (a)** The position vector for the +q on the positive x-axis is $a\hat{i}$ and position vector for the +q charge the negative x-axis is - $a\hat{i}$ So the dipole moment is,

$\vec{p} = (+q)(a\hat{i}) + (+q)(-a\hat{i}) = 0$

Case (b) In this case one charge is placed at the origin, so its position vector is zero. Hence only the second charge +q with position vector $a\hat{i}$ contributes to the dipole moment, which is $\vec{p} = qa\hat{i}$.

From both cases (a) and (b), we can infer that in general the electric dipole moment depends on the choice of the origin and charge configuration. But for one special case, the electric dipole moment is independent of the origin. If the total charge is zero, then the electric dipole moment will be the same irrespective of the choice of the origin. It is because of this reason that the electric dipole moment of an electric dipole (total charge is zero) is always directed from –q to +q, independent of the choice of the origin.

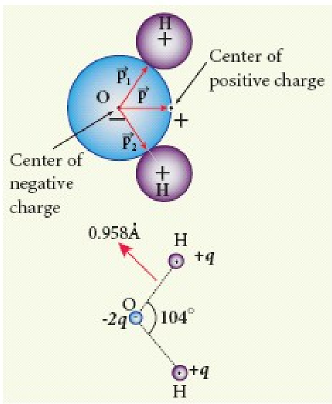
Case (c) $\vec{p} = (-2q)a\hat{j} + q(2a)(-\hat{j}) = -4qa\hat{j}$

Note that in this case $\vec{p}$ is directed from -2q to +q.

Case (d) $\vec{p} = -2qa(-\hat{i}) + qa\hat{j} + qa(-\hat{j})$

= $2qa\hat{i}$.

The water molecule (H_2O) has this charge configuration. The water molecule has three atoms (two H atom and one O atom). The centers of positive (H) and negative (O) charges of a water molecule lie at different points, hence it possess permanent dipole moment. The electric dipole moment $\vec{p}$ is directed from center of negative charge to the center of positive charge, as shown in the figure.



3) A sample of HCl gas is placed in a uniform electric field of magnitude 3 x 10^4 NC^{-1}. The dipole moment of each HCl molecule is 3.4 x 10^{-30} Cm. Calculate the maximum torque experienced by each HCl molecule.

Answer : The maximum torque experienced by the dipole is when it is aligned perpendicular to the applied field.

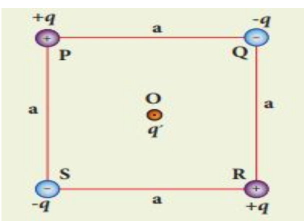
τ_{max} = pE sin 90^0 = 3.4 x 10^{-30} x 3 x 10^4 Nm

τ_{max} = 10.2 x 10^{-26} Nm.

4) Four charges are arranged at the corners of the square PQRS of side an as shown in the figure.

(a) Find the work required to assemble these charges in the given configuration.

(b) Suppose a charge q is brought to the center of the square, by keeping the four charges fixed at the corners, how much extra work is required for this?



Answer : (a) The work done to arrange the charges in the corners of the square is independent of the way they are arranged. We can follow any order.

(i) First, the charge +q is brought to the corner P. This requires no work since no charge is already present, $W_P = 0$

(ii) Work required to bring the charge –q to the corner Q = (-q) x potential at a point Q due to +q located at a point P

$W_Q = -q \times \frac{1}{4\pi\varepsilon_0}\frac{q}{a} = -\frac{1}{4\pi\varepsilon_0}\frac{q^2}{a}$

(iii) Work required to bring the charge +q to the corner R = q x potential at the point R due to charges at the point P and Q.

$W_R = q \times \frac{1}{4\pi\varepsilon_0}\left(-\frac{q}{a} + \frac{q}{\sqrt{2}a}\right)$

$= \frac{1}{4\pi\varepsilon_0}\frac{q^2}{a}\left(-1 + \frac{1}{\sqrt{2}}\right)$

(iv) Work required to bring the fourth charge –q at the position S = q × potential at the point S due the all the three charges at the point P, Q and R.

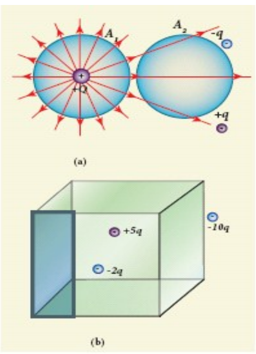
$W_s = -q \times \frac{1}{4\pi\varepsilon_0}\left(\frac{q}{a} + \frac{q}{a} - \frac{q}{\sqrt{2}a}\right)$

$W_s = -\frac{1}{4\pi\varepsilon_0}\frac{q^2}{a}\left(2 - \frac{1}{\sqrt{2}}\right)$

(b) Work required to bring the charge q′ to the center of the square = q′ x potential at the center point O due to all the four charges in the four corners.

The potential created by the two +q charges are canceled by the potential created by the -q charges which are located in the opposite corners. Therefore the net electric potential at the center O due to all the charges in the corners is zero.

Hence no work is required to bring any charge to the point O. Physically this implies that if any charge q′ when brought close to O, then it moves to the point O without any external force.

5) 

(i) In figure (a), calculate the electric flux through the closed areas A_1 and A_2.

(ii) In figure (b), calculate the electric flux through the cube.

Answer : (i) In figure (a), area A_1 encloses the charge Q. So electric flux through this closed surface A_1 is $\frac{Q}{\varepsilon_0}$. But the closed surface A_2 contains no charges inside, so electric flux through A_2 is zero.

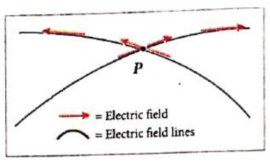
(ii) In figure (b), the net charge inside the cube is 3q and the total electric flux in the cube is therefore $\Phi_E = \frac{3q}{\varepsilon_0}$.

Note that the charge -10 q lies outside the cube and it will not contribute the total flux through the surface of the cube.

6) The electric field lines never intersect. Justify.

Answer : (i) No two electric field lines intersect each other. If two lines cross at a point, then there will be two different electric field vectors at the same point.

(ii) As a consequence, if some charge is placed in the intersection point, then it has to move in two different directions at the same time, which is physically impossible. Hence electric field lines do not intersect.



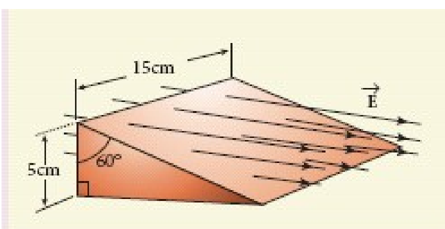
7) Define 'electric flux'.

Answer : The number of electric field lines crossing a given area kept normal to the electric field lines is called electric flux.

8) Write a short note on 'electrostatic shielding'.

Answer : Electrostatic shielding is the process of isolating a certain region of space from external field. It is based on the fact that electric field inside a conductor is zero. This property is called elecrostatic shielding because anything placed inside the cavity of the conductor will be completely shielded from external fields.

9) A closed triangular box is kept in an electric field of magnitude $E = 2 \times 10^3$ NC^{-1} as shown in the figure.



Calculate the electric flux through the

(a) vertical rectangular surface

(b) slanted surface and

(c) entire surface.

Answer : E = 2 x 10^3 N C^{-1}

Φ = EA cos θ

a) Vertical rectangular surface :

$\phi_{\text{vertical surface}} = EA\cos 180^o$

$\phi_{vs} = \left(-2\times 10^3\right)\times(0.05\times 0.15)$

$\phi_{vs} = -15\text{Nm}^2/\text{C}$

b) Slanted Surface :

$\phi_{\text{slanted surface}} = \text{EA}\cos 60^\circ$

Here, cos 60^o = 1/2

$\text{hyp} = \frac{5\text{ cm}}{\sin 30^\circ} = \frac{5}{1/2} = 10\text{ cm} = 0.1\text{ m}$

$\phi_{\text{slanted surface}} = \frac{1}{2}EA,$

$\phi_{ss} = \frac{1}{2}\left(2\times 10^3\right)\times(0.1\times 0.15)$

$\phi_{\text{as}} = 15\text{Nm}^2/\text{C}$

(c) Entire Surface :

$\phi_{\text{entire surface}} = \phi_{vs} + \phi_{\text{slanted}} + \phi_{\text{ends}}$

$\phi_{\text{end suffuce}} = \text{EA}\cos 90^\circ 0$

$\phi_{\text{entire surface}} = -15+15+0$

$\phi_{\text{entire surface}} = 0$

10) Define 'electrostatic potential".

Answer : The electric potential at a point P is equal to the work done by an external force to bring a unit positive charge with constant velocity from infinity to the point P in the region of the external electric field $\vec{E}$.

$V = \frac{1}{4\pi\varepsilon_0}\frac{q}{r}$

11) (i) Two insulated charged copper spheres A & B of identical size have charges qn and -3q_A respectively. When they are brought in contact with each other and then separated. What are the new charges on them?

(ii) When third sphere of some size but uncharged is brought in contact with first and then second and finally removed? What are the new charges.

Answer : (i) Charge on each sphere $= \frac{q_A - 3q_A}{2} = -q_A$

(ii)New charge on A is $\frac{q_A}{2}$

New charge on B is $\frac{q_A(2q_B)}{4}$

$\because \frac{\frac{q_A}{2}+q_B}{2} = \frac{q_A}{4} + \frac{q_B}{2} = \frac{q_A+2q_B}{4}$

q_B = -3q_A

∵ q_B = -3q_A

∴ New charge on B_1 is $\frac{q_A - 6q_A}{4}$

New charge on B $-\frac{5}{4}q_A$

12) How does the energy stored in a capacitor change it

(i) after disconnecting the battery, the plates of a charged capacitor are moved faster.

(ii) The battery remaining connected capacitance c ∝ $\frac{1}{d}$, when plates of capacitor.

Answer : (i) After disconnecting the battery, the charge on capacitor remains constant.

∴ energy stored capacitor $\left(U = \frac{q^2}{2C}\right)$

(ii) As the battery remains connected, the potential difference remains constant.

Hence energy stored U = $\frac{1}{2}$ CV^2 decreases.

13) Two charge d spherical conditioners of radii R_1 & R_2 when connected by a conducting wire acquire charges q_1 & q_2 respectively. Find the ratio of surface charge densities in terms of their radii.

Answer : The charges will flow between the two spherical conditioners till their potential become equal.

$i.e. \frac{Kq_1}{R_1} = \frac{Kq_2}{R_2} (or) \frac{q_1}{R_1} = \frac{q_2}{R_2}$

The ratio of the surface charge densities on the two conditioners will be

$$\frac{\sigma_1}{\sigma_2} = \frac{\frac{q_1}{4\pi R_1^2}}{\frac{q_2}{4\pi R_2^2}} = \frac{q_1}{q_1} \cdot \frac{R_2^2}{R_1^2} = \frac{R_1}{R_2} \times \frac{R_2^2}{R_1^2}$$

$$\frac{\sigma_1}{\sigma_2} = \frac{R_1}{R_2}$$

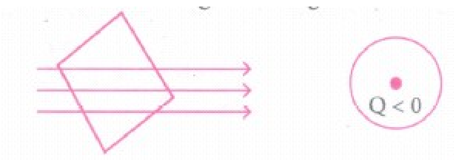
14) Draw equipotential surface

(i) in a uniform electric field and

(ii) for a point charge (Q < 0)

Answer : (i) The equipotential surface is ⊥r the electric field.

(ii) The equipotential surface will be a spherical shell with the given charge at the centre



15) When an object is said to be electrically neutral?

Answer : If the net charge in an object is zero then, it is said to be electrically neutral.

16) What is meant by triboelectric charging?

Answer : Charging the objects through rubbing is called 'triboelectric' charging.

17) What is the nature of the electric field? State its unit.

Answer : The Electric field is a vector quantity. Its unit is newton per coulomb (NC^{-1}).

18) In the following equation $\vec{F}_{21} = \frac{kq_1q_2}{r^2}\hat{r}_{12}$ What is the value of k?

Answer : The value of k is 9×10^9 Nm^2C^{-2} and $k = \frac{1}{4\pi\varepsilon_n}$ where ε_0 - permittivity of free space = 8.85×10^{-12} $C^2N^{-1}m^{-2}$

19) Define the physical quantity whose unit is Vm, and state whether it is scalar or vector.

Answer : The physical quantity whose unit is V m is electric flux. The number of electric field lines crossing a given area kept normal to the electric field lines is called electric flux. It is scalar quantity and its unit is N m^2 C^{-1} or V m.

20) what is electrostatics?

Answer : The branch of electricity which deals with stationary charges is called Electrostatics.