PHYSICS WALLAH

LAKSHYA
NEET

CLASS-XII

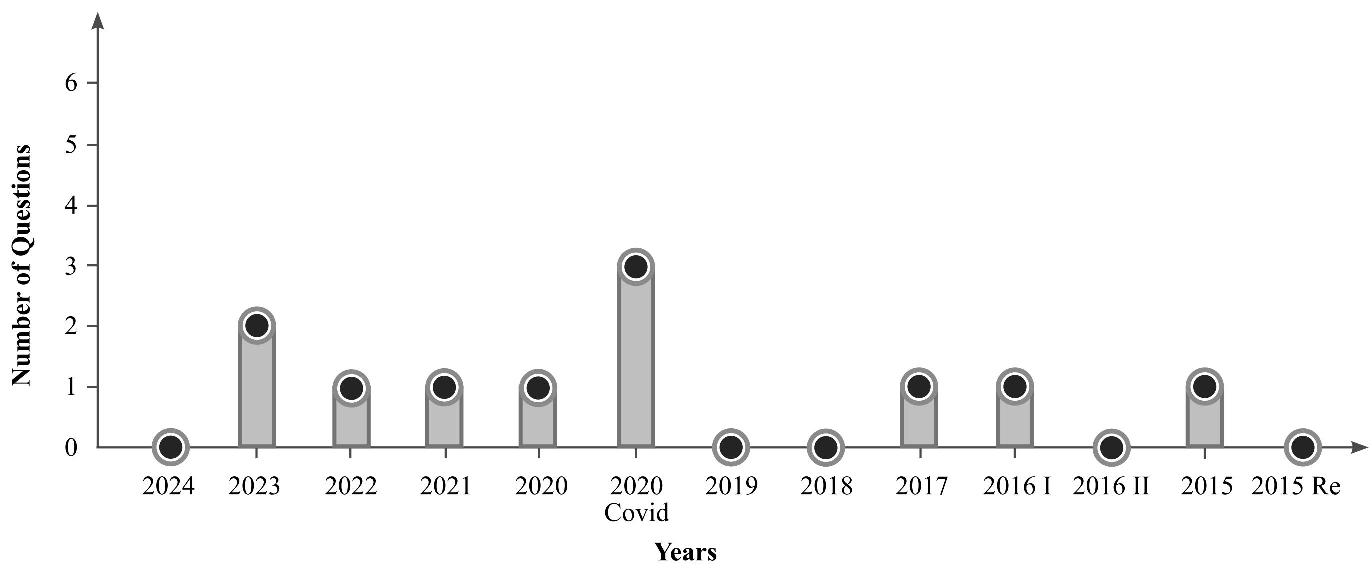
- Electric Charges and Fields
- Electrostatic Potential and Capacitance
- Current Electricity

PHYSICS
Module 1

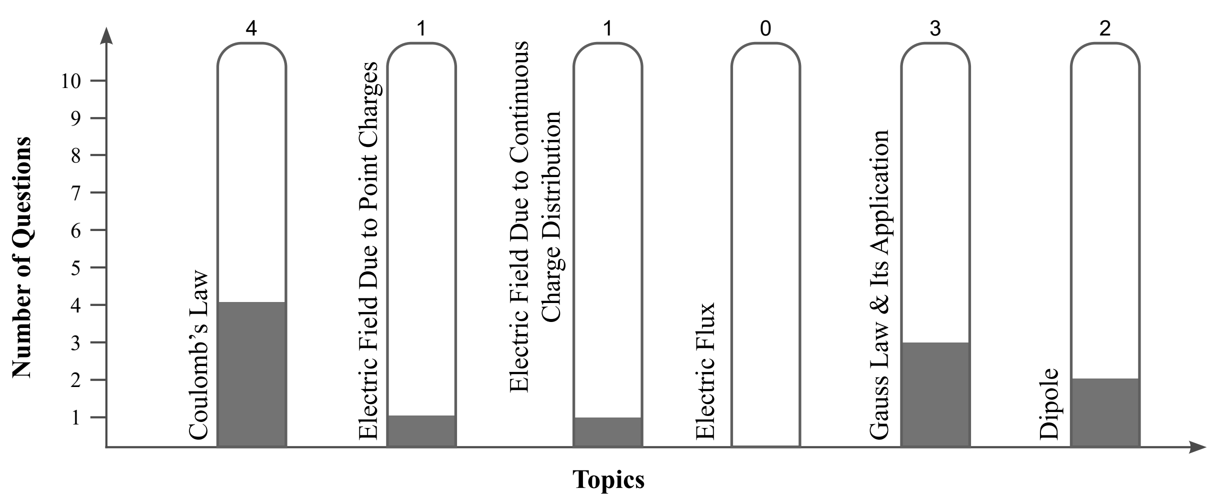
CHAPTER 1

Electric Charges and Fields

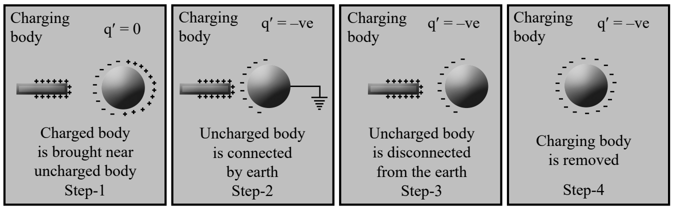
Year Wise Number of Questions Analysis (2024-2015)



Topicwise Number of Questions Analysis (2024-2015)



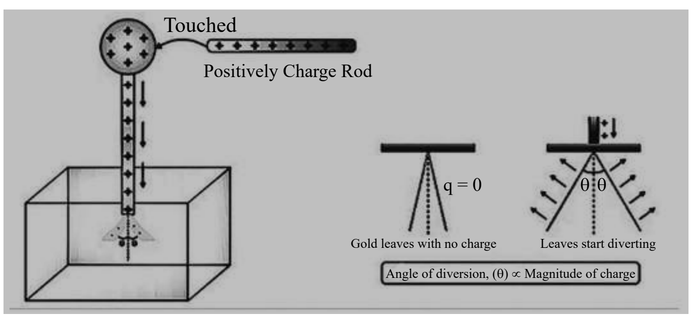
Charging a body by induction (in four successive steps)



Gold leaf electroscope

1. Gold leaf electroscope is a simple apparatus to detect charge on a body.
2. It consists of a vertical metal rod, housed in a box with thin gold leaves attached to its bottom end. The body whose charge is to be determined is touched to the sphere attached at the top of the electroscope. As the charge flows to the vertical rod in the apparatus, the gold leaves divert, thereby indicating the charge.

   A gold leaf electroscope is a simple device used to detect the charge on a body. When the body is touched to the sphere at the top of the electroscope, the charge flows down the metal rod, causing the thin gold leaves at the bottom to diverge. The angle of diversion between the leaves is related to the magnitude of the charge on the body. A larger angle typically indicates a greater charge.



Train Your Brain

Example 1: What is the total charge of a system containing five charges +1, +2, –3, +4 and –5 in some arbitrary unit?

Sol. Total charge is + 1 + 2 – 3 + 4 – 5 = –1 in the same unit.

Example 2: How many electrons are there in one coulomb of charge?

Sol. $n = \dfrac{Q}{e} = \dfrac{1\text{ coulomb}}{1.6\times10^{-19}\text{ coulomb}} = 6.25 \times 10^{18}$ electrons.

Example 3: Which of the following charge is not possible?

(1) 1.6×10^{-18} C (2) 1.6×10^{-19} C
(3) 1.6×10^{-20} C (4) 1.6×10^{-5} C

Sol. 1.6×10^{-20} C, because this is 1/10 of electronic charge and hence not an integral multiple of charge of electron. So option 3 is correct.

Example 4: An electron at rest has a charge of 1.6×10^{-19} C. It starts moving with a velocity $v = \dfrac{c}{2}$, where c is the speed of light, then the new charge on it is:

(1) 1.6×10^{-19} coulomb

(2) $1.6 \times 10^{-19}\sqrt{1-\left(\dfrac{1}{2}\right)^2}$ coulomb

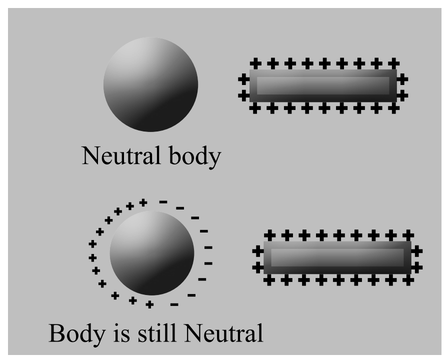
(3) $1.6 \times 10^{-19}\sqrt{\left(\dfrac{2}{1}\right)^2-1}$ coulomb

(4) $\dfrac{1.6\times10^{-19}}{\sqrt{1-\left(\dfrac{1}{2}\right)^2}}$ coulomb

Sol. Charge does not depend on velocity. So, Option 1 is correct.

Example 5: If a charged body is put near a neutral conductor, will it attract the conductor or repel it?

Sol.



They attract each other due to induction effect.

Example 6: How many electrons must be removed from a body to make it electrified by 3.2 C of charge?

Sol. From $Q = ne$

$\Rightarrow n = \dfrac{Q}{e} = \dfrac{3.2}{1.6\times10^{-19}}$

$\Rightarrow n = 2 \times 10^{19}$

Example 7: In 1 g of a solid, there are 5×10^{21} atoms. If one electron is removed from 0.01% atoms of the solid, the charge gained by the solid is;

(1) + 0.08C (2) + 0.8C
(3) – 0.08C (4) – 0.8C

Sol. 0.01% of $5 \times 10^{21} = \dfrac{5\times10^{21}\times0.01}{100} = 5 \times 10^{17}$

$\therefore$ Charge gained $= 5 \times 10^{17}\, e$

$= 5 \times 10^{17} \times 1.6 \times 10^{-19} = +\,0.08$ C

So option 1 is correct.

Concept Application

1. The electric charge in uniform motion produces;
   (1) An electric field only
   (2) A magnetic field only
   (3) Both electric and magnetic field
   (4) Neither electric nor magnetic field
2. The weight of a body which is charged negatively by rubbing;
   (1) Remain constant
   (2) Decreases
   (3) Increases
   (4) May increase or may decrease
3. Which of the following option is correct?
   (1) The total number of charged particles in the universe remains conserved.
   (2) The magnitude of total positive charge of the universe is constant.
   (3) The magnitude of total negative charge of the universe is constant.
   (4) The total charge of the universe is constant.
4. If a glass rod is rubbed with silk, it acquires a positive charge because;
   (1) protons are added to it
   (2) protons are removed from it
   (3) electrons are added to it
   (4) electrons are removed from it
5. Which one of the following statement regarding electrostatics is wrong?
   (1) Charge is quantized
   (2) Charge is conserved
   (3) There is an electric field near an isolated charge at rest
   (4) A stationary charge produces both electric and magnetic fields
6. In nature, the electric charge of any system is always equal to;
   (1) half integral multiple of the least amount of charge
   (2) zero
   (3) one third of the least amount of charge
   (4) integral multiple of the least amount of charge

COULOMB'S LAW

Coulomb's law states that the magnitude of the electrostatic force of attraction or repulsion between two stationary point charges is directly proportional to the product of the magnitudes of charges and inversely proportional to the square of the distance between them.

$$F = \frac{1}{4\pi \in_0} \frac{q_1 q_2}{d^2} \quad \text{(in air or vaccum)}$$

$$F = \frac{kq_1q_2}{d^2}, \text{ where } K = \frac{1}{4\pi\varepsilon o}$$

❖ $\in_0 = 8.857 \times 10^{-12} \frac{C^2}{Nm^2}$ or $\frac{farad}{metre}$,

and $\frac{1}{4\pi \in_0} = 9 \times 10^9 \, Nm^2 / C^2 = k$ (say)

Relative permitivity ($\in_r$): The relative permitivity is the ratio of absolute permitivity of the medium to the absolute permitivity of the free space $\in_r = \frac{\in}{\in_0} = K$ (dielectric constant)

$\in_r$ has no units and dimensional formula is [M° L°T° A°]

and also $\in_r = \frac{\text{Force between two charges in air}}{\text{(Force between the same two charges in the medium at same distance)}}$

$$= \frac{F_{air}}{F_{medium}}$$

❖ For air $K = 1$
$K > 1$ for any dielectric medium;
$K = \infty$ for conducting medium like metals

Force between two charges in a medium

❖ $F = \frac{1}{4\pi \in_0 \in_r} \frac{q_1 q_2}{d^2} = \frac{1}{4\pi \in_0 K} \frac{q_1 q_2}{d^2}$

(Net force on either charges in a medium)

$\in_0$-permitivity of free space or vacuum or air.

$\in_r(K)$ = Relative permitivity or dielectric constant of the medium in which the charges are situated.

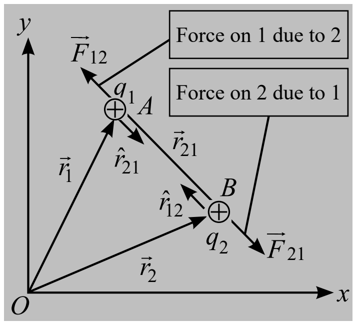
Comparison of Electrostatic and Gravitational Force

1. **Identical Properties:**
   - ❖ Both the forces are central forces, i.e., they act along the line joining the centers of two charged bodies.
   - ❖ Both the forces obey inverse square law,
   - ❖ Both are conservative forces, i.e. the work done by them is independent of the path followed.
   - ❖ Both the forces are effective even in free space.
2. **Non identical properties:**
   - ❖ Gravitational forces are always attractive in nature while electrostatic forces may be attractive or repulsive.
   - ❖ Gravitational constant of proportionality does not depend upon medium, the electrical constant of proportionality depends upon medium.
   - ❖ Electrostatic forces are extremely large as compared to gravitational forces

Coulomb's Law in Vector Form

Let q, and q_2 be two like charges placed at points A and B, respectively, in vacuum. $\vec{r_1}$ is the position vector of point A, and

$\vec{r}_2$ is the position vector of point B. Let $\vec{r}_{21}$ be vector from A to B, then



$$\vec{r}_{21} = \vec{r}_2 - \vec{r}_1$$

and $|\vec{r}_{21}| = r = |\vec{r}_2 - \vec{r}_1|$

$$\hat{r}_{21} = \frac{\vec{r}_{21}}{r} = \frac{\vec{r}_2 - \vec{r}_1}{|\vec{r}_2 - \vec{r}_1|}$$

From figure it is clear that $\vec{F}_{21}$ and $\hat{r}_{21}$ are in the same direction, so

$$\vec{F}_{21} = \frac{1}{4\pi\varepsilon_0}\frac{q_1q_2}{r^2}\hat{r} = \frac{1}{4\pi\varepsilon_0}\frac{q_1q_2}{r^2}\frac{\vec{r}}{r} = \frac{q_1q_2}{4\pi\varepsilon_0}\frac{\vec{r}}{r^3}$$

$$= \frac{q_1q_2}{4\pi\varepsilon_0}\frac{\vec{r}_2 - \vec{r}_1}{|\vec{r}_2 - \vec{r}_1|}$$

The above equations give the Coulomb's law in vector form. As we know that charges apply equal and opposite forces on each other, we have $\vec{F}_{12} = -\vec{F}_{21}$

or $\vec{F}_{12} = \frac{q_1q_2}{4\pi\varepsilon_0}\frac{\vec{r}_1 - \vec{r}_2}{|\vec{r}_1 - \vec{r}_2|^3}$

We can also write in terms of unit vector notation:

$$\vec{F}_{12} = \frac{1}{4\pi\varepsilon_0}\frac{q_1q_2}{r^2}\hat{r}_{12}$$

where $\hat{r}_{12}$ is a unit vector directed toward q_1, from q_2. This force of Coulomb's law is illustrated in figure. For three different point charge distributions, we have $\hat{r}_{12} = -\hat{r}_{21}$. So

$$\vec{F}_{12} = \frac{1}{4\pi\varepsilon_0}\frac{q_1q_2}{r^2}\hat{r}_{12} = \frac{1}{4\pi\varepsilon_0}\frac{q_2q_1}{r^2}(-\hat{r}_{21})$$

$$= -\frac{1}{4\pi\varepsilon_0}\frac{q_2q_1}{r^2}\hat{r}_{21} = -\vec{F}_{21}$$

Principle of Superposition

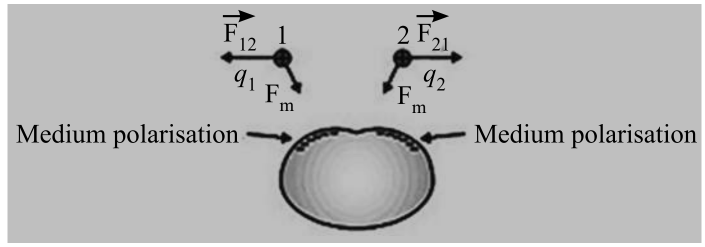
The principle of superposition states that for a system of charges $q_1, q_2, ..., q_n$, the force on q_1 due to q_2 is the same as given by Coulomb's law, *i.e.*, it is unaffected by the presence of the other charges $q_3, q_4, ..., q_n$. The total force $\vec{F}_1$ on the charge q_1, due to all other charges is given by the vector sum of the forces $\vec{F}_{12}, \vec{F}_{13}, ..., \vec{F}_{1n}$:

i.e., $\vec{F}_1 = \vec{F}_{12} + \vec{F}_{13} + ... + \vec{F}_{1n} = \frac{1}{4\pi\varepsilon_0}\left[\frac{q_1q_2}{r_{12}^2}\hat{r}_{12} + \frac{q_1q_3}{r_{13}^2}\hat{r}_{13} + ... + \frac{q_1q_n}{r_{1n}^2}\hat{r}_{1n}\right]$

$$\vec{F}_1 = \frac{q_1}{4\pi\varepsilon_0}\sum_{i=2}^{n}\frac{q_i}{r_{1i}^2}\hat{r}_{1i}$$

Force Affected by a Medium

When a medium is in close vicinity of two point charges, then the medium gets polarised.



Due to polarization, medium also starts applying force on the charges.

$$\vec{F}_{Net} = \vec{F}_0 - \vec{F}_m$$

$\vec{F}_{Net}$ ↑	$\vec{F}_0$ ↑	$\vec{F}_m$ ↑
Net force	Force in Vaccum	Force appliecd by medium

$$\frac{F_0}{\in_r} = F_0 - F_m$$

$$\boxed{F_m = F_0\left(1 - \frac{1}{\in_r}\right)}$$

where, $\in_r$ = Relative permittivity of medium or dielectric constant of medium.

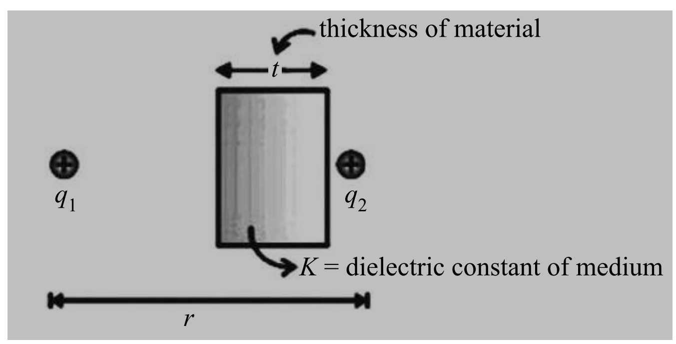
Conclusion

From the above result, it can be seen that the net force (F_{Net}) between the charges decreases. It happens because of the polarization of medium.

Also, note that Coulomb's force between the charges is not affected by any medium. The decrease in the net force is because of an additional force due to medium polarisation.

Force of Interaction between Charges if Space between them is Partially Filled

Consider the following figure in which a dielectric slab of thickness t is kept in between the two charges q_1 and q_2.



In such a case, the separation (r) between the charges is to be replaced by an effective distance given by, $r' = (r - t) + t\sqrt{k}$

The net force between the charges then becomes,

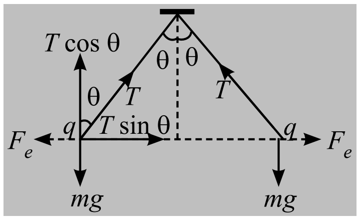
$$\boxed{F_{net} = \frac{1}{4\pi\in_0}\times\frac{q_1q_2}{r'^2}}$$

where, r' = effective distance between the charges.

Force between Multiple Charges

Equilibrium of suspended point charge system (Pith Ball problems)

When two identically charged pith balls are suspended from a common point of suspension by equal-length insulated cords, if each ball has mass m then the problem related to it can be treated as.



$T \sin\theta = F_e$ ...(*i*)

$T \cos\theta = mg$ ...(*ii*)

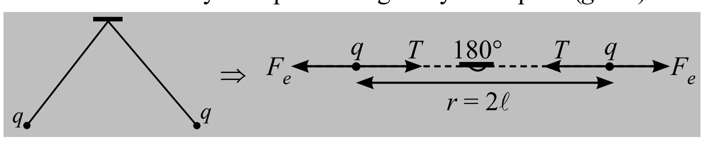
$\tan\theta = \dfrac{F_e}{mg}$ ...(*iii*)

$r = 2\ell \sin\theta$ (distance between charges, where ℓ is length of of string)

$$F_e = \frac{kq^2}{r^2} = \frac{kq^2}{4\ell^2 \sin^2\theta}$$

$$T = \sqrt{(F_e)^2 + (mg)^2}$$

Case-1: If whole system placed in gravity free space ($g = 0$)

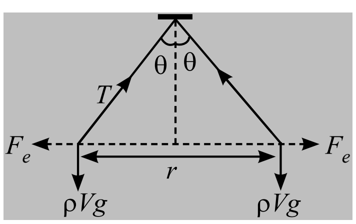


$$F_e = \frac{kq^2}{r^2} = \frac{kq^2}{4\ell^2}$$

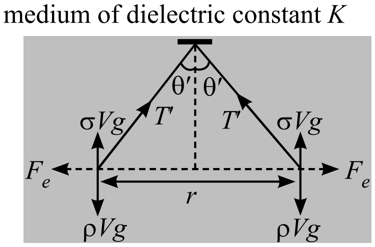
Tension in thread $T = \dfrac{kq^2}{4\ell}$

Case-2: If density of material is ρ and volume is V then

In air, $\tan\theta = \dfrac{F_e}{mg} = \dfrac{F_e}{V\rho g}$



Case-3: If experiment is done inside liquid having density σ and dielectric constant K then (Consider density of material is ρ and volume V). In medium of dielectric constant K



$$T' \sin\theta' = \frac{F_e}{K}$$

$$T' \cos\theta' + F_B = mg$$

$$T' \cos\theta' = \rho Vg - \sigma Vg$$

$$\tan\theta' = \frac{\frac{F_e}{K}}{(\rho Vg - \sigma Vg)}$$

In Air, $\tan\theta = \dfrac{F_e}{V\rho g}$

In Medium $\tan\theta' = \dfrac{\frac{F_e}{K}}{(\rho Vg - \sigma Vg)}$

$$\tan\theta' = \frac{F_e}{\rho VgK\left(\frac{\rho - \sigma}{\rho}\right)}$$

$$\tan\theta' = \frac{\tan\theta}{K\left(1 - \frac{\sigma}{\rho}\right)}$$

If $K\left(1 - \dfrac{\sigma}{\rho}\right) > 1$, $\theta' < \theta$

If $K\left(1 - \dfrac{\sigma}{\rho}\right) < 1$, $\theta' > \theta$

If $K\left(1 - \dfrac{\sigma}{\rho}\right) = 1$, $\theta' = \theta$

Electrostatic Equilibrium

The point where the resultant force on a charged particle becomes zero is called equilibrium position.

1. **Stable Equilibrium:** A charge is initially in equilibrium position and is displaced by a small distance. If the charge tries to return back to the same equilibrium position then this equilibrium is called position of stable equilibrium.
2. **Unstable Equilibrium:** If charge is displaced by a small distance from its equilibrium position and the charge has no tendency to return to the same equilibrium position. Instead it goes away from the equilibrium position.
3. **Neutral Equilibrium:** If charge is displaced by a small distance and it is still in equilibrium condition then it is called neutral equilibrium.

Limitations of Coulomb's Law

- Coulomb's law cannot be applied if the point charges are not at rest. The reason for this is that when the two charged particles are brought together, the distribution of charges on them changes.
- Coulomb's law cannot be applied if the shape of the charges is arbitrary because, in irregular shapes, it becomes difficult to determine the distance between the particles.

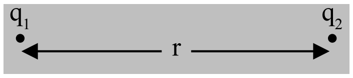
Short Notes

Coulomb's Law

Force between two charges $\vec{F} = \dfrac{1}{4\pi \in_0 \in_r} \dfrac{q_1 q_2}{r^2}\hat{r}$,

$\in_0$-permitivity of free space or vacuum or air.

$\in_r(K)$ = Relative permitivity or dielectirc constant of the medium in which the charges are situated.



Principle of Superposition

Force on a point charge due to many charges is given by

$$\vec{F} = \vec{F}_1 + \vec{F}_2 + \vec{F}_3 + ...$$

Notes: The force due to one charge is not affected by the presence of other charges.

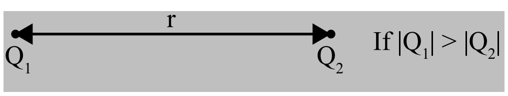
Electric Field or Electric Field Intensity (Vector Quantity)

$$\vec{E} = \frac{\vec{F}}{q}, \text{ unit is N/C or V/m.}$$

Electric Field Due to Point Charge Q

$$\vec{E} = \lim_{q_0 \to 0} \frac{\vec{F}}{q_0} = \frac{1}{4\pi \in_0} \frac{Q}{r^2}\hat{r}$$

Null Point for Two Charges



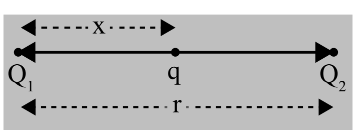
$\Rightarrow$ Null point near Q_2

$x = \dfrac{\sqrt{Q_1}\,r}{\sqrt{Q_1} \pm \sqrt{Q_2}}$; $x \to$ distance of null point from Q_1 charge

(+) for like charges

(–) for unlike charges

Equilibrium of Three Point Charges



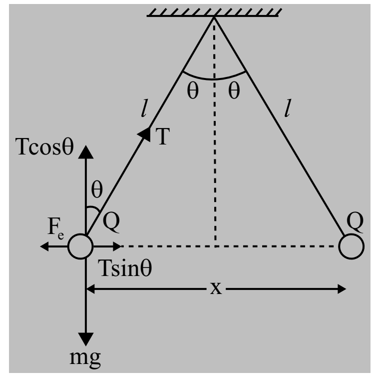
(i) Two charges must be of like nature.

(ii) Third charge should be of unlike nature.

$$x = \frac{\sqrt{Q_1}}{\sqrt{Q_1} + \sqrt{Q_2}}\,r \quad \text{and} \quad q = \frac{-Q_1 Q_2}{\left(\sqrt{Q_1} + \sqrt{Q_2}\right)^2}$$

Equilibrium of Suspended Point Charge System

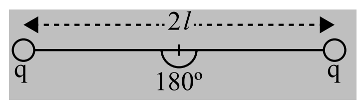
For equilibrium position



$$\Rightarrow \tan\theta = \frac{F_e}{mg} = \frac{kQ^2}{x^2 mg}$$

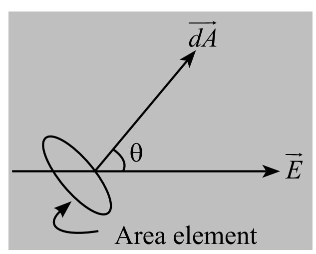
$$T = \sqrt{(F_e)^2 + (mg)^2}$$

If whole set up is taken into an artificial satellite ($g_{eff} \simeq 0$)



$$\Rightarrow T = F_e = \frac{kq^2}{4\ell^2}$$

Electric flux:



$$\phi = \int d\phi = \int \vec{E}.d\vec{A}$$

❖ If field is uniform $\Rightarrow \vec{E}$ = constant

$\phi = \vec{E}.\int d\vec{A}$ $\qquad \int d\vec{A}$ = total area vector of a plane surface

$$\Rightarrow \boxed{\phi = \vec{E}.\vec{A}}$$

$$\Rightarrow \boxed{\phi = EA\cos\theta}$$

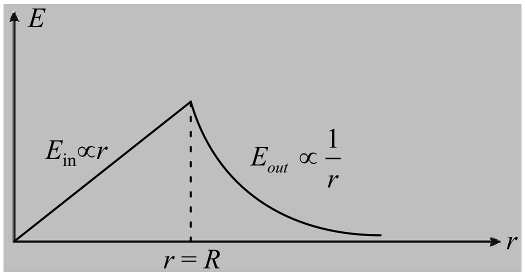
Electric Field due to Uniformly Charged Infinitely Long Solid Cylinder

(*i*) ***E* at outside point:**

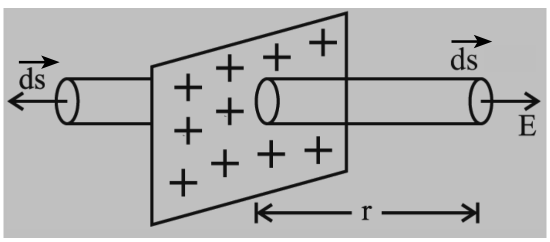
$$E_{out} = \frac{\rho R^2}{2r\,\varepsilon_0} \text{ (}\rho\text{-Volume charge density)}$$

(*ii*) ***E* at inside point:**

$$E_{in} = \frac{\rho r}{2\varepsilon_0}$$

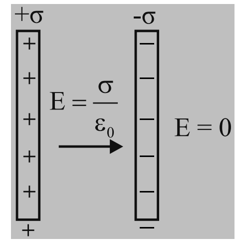


Electric Field Intensity due to a Uniformly Charged Infinite Plane Sheet



$$E = \frac{\sigma}{2\varepsilon_0}$$

Electric Field Intensity due to two Equally and Oppositely Charged Parallel Plane Sheets.

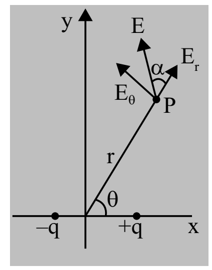


$$E = \frac{\sigma}{\varepsilon_0} \text{ (between two plates)}$$

$E = 0$ (outside the plates)

Electric Dipole

- Electric dipole moment $\vec{p} = q(2\vec{a})$
- Torque on dipole placed in uniform electric field $\vec{\tau} = \vec{p} \times \vec{E}$
- At a point which is at a distance r from dipole midpoint and making angle θ with dipole axis.



Electric field $E = \frac{1}{4\pi \in_0} \frac{p\sqrt{1+3\cos^2\theta}}{r^3}$

Direction $\tan\alpha = \frac{E_\theta}{E_r} = \frac{1}{2}\tan\theta$

- Electric field at axial point (or End-on) $\vec{E} = \frac{1}{4\pi \in_0} \frac{2\vec{p}}{r^3}$ of dipole
- Electric field at equatorial position (Broad-on) of dipole $\vec{E} = \frac{1}{4\pi \in_0} \frac{(-\vec{p})}{r^3}$
- Time period of SHM of dipole in uniform electric field

$$T = 2\pi\sqrt{\frac{I}{pE}}$$

1. Consider a neutral conducting sphere. A positive point charge is placed outside the sphere. The net charge on the sphere is

(1) Zero

(2) Negative and distributed uniformly over the surface of the sphere

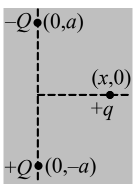
(3) Negative and distributed non-uniformly over the surface of the sphere

(4) Negative and appears only at the point on the sphere closest to the point charge

Sol. When a positive point charge is placed outside a conducting surface, redistribution of charges takes place on the surface. But the total charge is zero as no charge enters or loses the surface.

Therefore, option (1) is the correct answer.

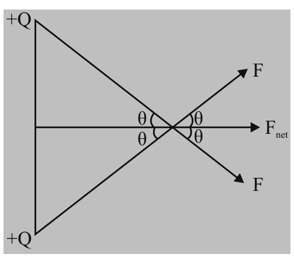
2. 3 point charges are placed as shown in the figure. The net force on charge q is



(1) $\dfrac{2KQqx^2}{\left(a^2+x^2\right)a^2}$ (2) $\dfrac{2KQqx}{\left(a^2+x^2\right)^{3/2}}$

(3) $\dfrac{KQqx}{\left(a^2+x^2\right)^{3/2}}$ (4) $\dfrac{3}{2}\dfrac{KQqx}{\left(a^2+x^2\right)^{3/2}}$

Sol.



$$F_{\text{net}} = 2F\cos\theta = 2\times\frac{KQq}{\left(a^2+x^2\right)}\frac{x}{\sqrt{a^2+x^2}} = \frac{2KQqx}{\left(a^2+x^2\right)^{3/2}}$$

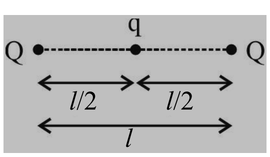
Therefore, option (2) is the correct answer.

3. Two equal charges 'Q' are placed at a distance l apart. A third charge 'q' is placed at mid-point between them such that entire system is in equilibrium. The value of charge q is

(1) $-\dfrac{Q}{4}$ (2) $\dfrac{Q}{4}$

(3) $\dfrac{Q}{2}$ (4) $-\dfrac{Q}{2}$

Sol.



$F_{\text{net}} = O$

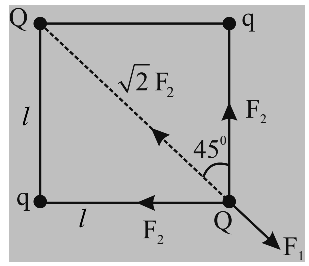
$$\Rightarrow \frac{KQ^2}{l^2}+\frac{KQq}{\left(\frac{l}{2}\right)^2} = 0 \Rightarrow q = -\frac{Q}{4}$$

Therefore, option (1) is the correct answer.

4. Charge Q is placed at each of the two diagonally opposite corner of a square. Also charge q is placed at each of the other two corners. If net force on charge Q is zero, then $\dfrac{Q}{q}$ is:

(1) $-2\sqrt{2}$ (2) -2 (3) $-\sqrt{2}$ (4) $\dfrac{1}{\sqrt{2}}$

Sol.



Let F_1 be the force between Q and Q. For the net force on Q to be zero, the force between Q and q should be attractive Let F_2 be the force between Q and q.

$\therefore$ Net force on Q is zero.

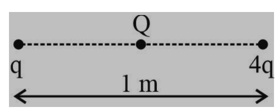
$2F_2\cos 45^0 = -F_1$

$$\therefore\ \sqrt{2}F_2 = -F_1 \Rightarrow \sqrt{2}\frac{KQq}{l^2} = -\frac{KQ^2}{(\sqrt{2}l)^2}$$

$$\Rightarrow \frac{Q}{q} = -2\sqrt{2}$$

Therefore, option (1) is the correct answer.

5. Considers the following system of two charges q and 4q, separated by a distance of 1m. Charge 'Q' is placed near them such that entire system comes in equilibrium. The value of charge Q is:



(1) $\dfrac{9}{4}q$ (2) $-\dfrac{4}{9}q$ (3) $\dfrac{2}{9}q$ (4) $\dfrac{5}{9}q$

Sol. Let the charge 'Q' is placed at a distance of 'r' from charge 'q'. For the system to be in equilibrium

$$\frac{KQq}{r^2} = \frac{KQ4q}{(1-r)^2} \Rightarrow r = \frac{1}{3}$$

Force on 'q' due to '$4q$'

$$F_1 = \frac{Kq\times 4q}{1^2}$$

Force on 'q' due to Q

Board Level Problems

MULTIPLE CHOICE QUESTIONS

1. If a body has positive charge on it, then it means it has
(1) Gained some protons
(2) Lost some protons
(3) Gained some electrons
(4) Lost some electrons

2. Sure, check for presence of electric charge on two bodies is
(1) Process of induction
(2) Repulsion between bodies
(3) Attraction between bodies
(4) Frictional force between bodies

3. If a solid and a hollow conducting sphere have same radius then
(1) Hollow sphere will hold more maximum charge
(2) Solid sphere will hold more maximum charge
(3) Both the spheres will hold same maximum charge
(4) Both the sphere can't hold charge

4. When a conducting soap bubble is negatively charged then
(1) Its size starts varying arbitrarily
(2) It expands
(3) It contracts
(4) No change in its size takes place

5. Consider three-point objects P, Q and R, R and Q repel each other, while P and R attract. What is the nature of force between P and Q?
(1) Repulsive force (2) Attractive force
(3) No force (4) Data not sufficient

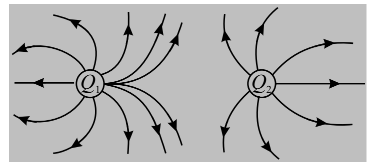
6. Which of the following processes involves the principle of electrostatic induction?
(1) Pollination (2) Chocolate making
(3) Xerox copying (4) All of these

7. The electric field intensity at a point in vacuum is equal to
(1) Zero
(2) Force a proton would experience there
(3) Force an electron would experience there
(4) Force a unit positive charge would experience there

8. A sphere of radius has electric charge uniformly distributed in its entire volume. At a distance d from the centre inside the sphere the electric field intensity is directly proportional to
(1) $\frac{1}{d}$ (2) $\frac{1}{d^2}$ (3) d (4) d^2

9. The electric field at distance 2R from the centre of a uniformly charged non-conducting sphere of radius is R is E. The electric field at a distance $R/2$ from the centre will be
(1) Zero (2) $2E$ (3) $4E$ (4) $16E$

10. Figure shows electric lines of forces due to charges and Hence



(1) Q_1 and Q_2 both are negative
(2) Q_1 and Q_2 both are positive
(3) $Q_1 > Q_2$
(4) Both (2) and (3)

ASSERTION AND REASON QUESTIONS

Directions: These questions consist of two statements each, printed as Assertion and Reason. While answering these questions, you are required to choose any one of the following four responses.
(1) Both Assertion and Reason are True and the Reason is a correct explanation of the Assertion.
(2) Both Assertion and Reason are True but Reason is not a correct explanation of the Assertion.
(3) Assertion is True but the Reason is False.
(4) Assertion is False but Reason is True.

1. Assertion (A): When an electric dipole is placed in uniform electric field, net force on it will be zero.
Reason (R): Force on the constituent charges of the dipole will be equal and opposite when it is in uniform electric field.

2. Assertion (A): Gauss' theorem is applicable on any closed surface.
Reason (R): In order to find the value of electric field due to a charge distribution, Gauss' theorem should be applied on a symmetrical closed surface.

3. Assertion (A): The number of field lines drawn from a charge is proportional to the magnitude of the charge.
Reason (R): The electric field at any point is proportional to the magnitude of the source charge.

VERY SHORT ANSWER QUESTIONS

1. In an electric field an electron is kept freely. If the electron is replaced by a proton, what will be the relationship between the forces experienced by them?
2. Which orientation of an electric dipole in a uniform electric field would correspond to stable equilibrium?
3. When two electrically charged particles having charges of different magnitude are placed at a distance from each other, they experience a force of attraction . These two particles are put in contact and again placed at the same distance from each other. What is the nature of new force between them?
4. Can a charged body attract an uncharged body?
5. The force between two charges placed in vacuum is F. What happens to the force if the two charges are dipped in kerosene oil of dielectric constant, $k = 2$?
6. What is the line of symmetry of a dipole field?
7. Find the value of electric field that would exactly balance the weight of electron.

Prarambh Exercise-1 (Topicwise)

COULOMB'S LAW

1. One million electrons are added to a glass rod. The total charge on the rod is

(1) 10^{-13} C (2) -1.6×10^{-13} C
(3) $+1.6 \times 10^{-12}$ C (4) 10^{-12} C

2. A body has a charge of 9.6×10^{-20} coulomb. It is

(1) Possible
(2) Not possible
(3) May (or) may not possible
(4) Data not sufficient

3. A force of 4N is acting between two charges in air. If the space between them is completely filled with glass ($\varepsilon_r = 8$), then the new force will be

(1) 2N (2) 5N
(3) 0.2N (4) 0.5N

4. Two identical metal spheres possess +60C and –20C of charges. They are brought in contact and then separated by 10 cm. The force between them is

(1) 36×10^{13}N (2) 36×10^{14}N
(3) 36×10^{12}N (4) 36×10^{11}N

5. Which of the following law gives existence of force between two stationary charged particles?

(1) Coulomb's law (2) Biot-savart's law
(3) Ohm's law (4) All of these

6. Electric charge of any system is

(1) Zero or neutral
(2) Half integral multiple of the least amount of charge
(3) Integral multiple of least amount of charge
(4) One third the least amount of charge

7. Two charged particles having charge 2×10^{-8}C each are joined by an insulating string of length 1m and the system is kept on a smooth horizontal table, what is the tension in the string?

(1) 3.6×10^{-6}N (2) 3.4×10^{-6}N
(3) 4×10^{-7}N (4) 3×10^{-4}N

8. How many electrons must be removed from a piece of metal to give it a positive charge of 1×10^{-7}C?

(1) 6.25×10^{-11} (2) 6.25×10^{-12}
(3) 6.25×10^{11} (4) 6.25×10^{13}

9. Two charged spheres separated at a distance R exert a force F on each other. If they are immersed in a liquid of dielectric constant 5 then what is the new force between them

(1) $\frac{F}{5}$ (2) F (3) 5F (4) $\frac{F}{2}$

10. Charges on two spheres are +10μC and –5μC respectively. They experience a force F. If each of them is given an additional charge +2μC then new force between them keeping the same distance is

(1) 18F (2) $\frac{F}{25}$ (3) $\frac{18F}{25}$ (4) $\frac{25}{18}F$

11. Three charges q_1, q_2, q_3 each equal to q placed at the vertices of an equilateral triangle of side l. What will be the force on a charge Q placed at the centroid of triangle?

(1) $\frac{1}{4\pi \epsilon_0}\frac{q^2}{l^2}$ (2) $\frac{1}{4\pi \epsilon_0}\frac{3q^2}{l^2}$
(3) $\frac{1}{4\pi \epsilon_0}\frac{2q^2}{l^2}$ (4) Zero

12. Total charge Q is broken in two parts Q_1 & Q_2 and they are placed at a distance R from each other. The maximum force of repulsion between them will occur when

(1) $Q_2 = \frac{Q}{4}, Q_1 = Q - \frac{Q}{4}$ (2) $Q_2 = \frac{Q}{3}, Q_1 = Q - \frac{Q}{3}$
(3) $Q_2 = \frac{Q}{4}, Q_1 = Q - \frac{3Q}{4}$ (4) $Q_2 = \frac{Q}{2}, Q_1 = Q - \frac{Q}{2}$

13. Two charges of +200μC and –200μC are placed at the corners B and C of an equilateral triangle ABC of side 0.1 m. The force on a charge of 5μC placed at A is

(1) 1800 N (2) $1200\sqrt{3}$N
(3) $600\sqrt{3}$N (4) 900 N

14. Two charges each of 1μC are at $P(2\hat{i}+3\hat{j}+\hat{k})$m and $Q(\hat{i}+\hat{j}-\hat{k})$m. Then the force between them is

(1) 100 N (2) 10 N
(3) 10^4 dyne (4) 100 dyne

15. A charge Q is divided into two parts q_1 and q_2 such that they experience maximum force of repulsion when separated by certain distance. The ratio of Q, q_1 and q_2 is

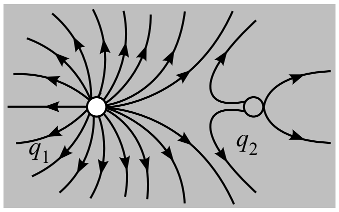
(1) 1 : 1 : 2 (2) 1 : 2 : 2
(3) 2 : 2 : 1 (4) 2 : 1 : 1

16. Three charges $-q$, $+q$ and $-q$ are placed at the corners of an equilateral triangle of side 'a'. The resultant electric force on a charge $+q$ placed at the centroid O of the triangle is

(1) $\frac{3q^2}{4\pi\varepsilon_0 a^2}$ (2) $\frac{q^2}{4\pi\varepsilon_0 a^2}$
(3) $\frac{q^2}{2\pi\varepsilon_0 a^2}$ (4) $\frac{3q^2}{2\pi\varepsilon_0 a^2}$

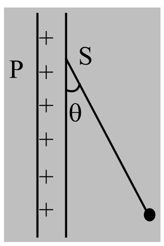
Prabal Exercise-2 (Learning Plus)

1. Figure shows electric field lines due to a charge configuration from this we conclude that



(1) q_1 and q_2 are positive and $q_2 > q_1$
(2) q_1 and q_2 are positive and $q_1 > q_2$
(3) q_1 and q_2 are negative and $|q_1| > |q_2|$
(4) q_1 and q_2 are negative and $|q_2| > |q_1|$

2. A charged ball B hangs from a silk thread S, which makes an angle θ with a large charged conducting sheet P, as shown in the figure. The surface charge density σ of the sheet is proportional to:

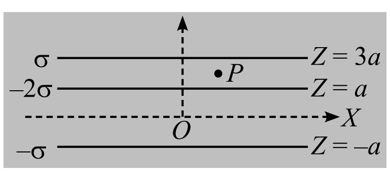


(1) sin θ (2) tan θ (3) cos θ (4) cot θ

3. A particle having charge q and mass m is projected with velocity $\vec{v} = 2\hat{i} - 3\hat{j}$ in a uniform electric field $\vec{E} = E_0\hat{j}$. Change in momentum Δp during any time interval t is given by?

(1) $\sqrt{13}\,m$ (2) qE_0t (3) $\dfrac{qE_0t}{m}$ (4) Zero

4. Three infinitely long charged sheets are placed as shown in figure. The electric field at point P is:



(1) $-\dfrac{2\sigma}{\varepsilon_0}\hat{k}$ (2) $\dfrac{2\sigma}{\varepsilon_0}\hat{k}$

(3) $-\dfrac{4\sigma}{\varepsilon_0}\hat{k}$ (4) $\dfrac{4\sigma}{\varepsilon_0}\hat{k}$

5. The electric field intensity outside a charged sphere of radius R at a distance r $(r > R)$ is

(1) $\dfrac{\sigma R^2}{\varepsilon_0 r^2}$ (2) $\dfrac{\sigma r^2}{\varepsilon_0 R^2}$

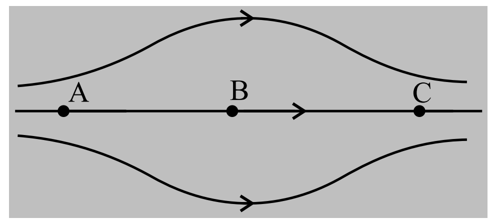
(3) $\dfrac{\sigma r}{\varepsilon_0 R}$ (4) $\dfrac{\sigma R}{\varepsilon_0 r}$

6. An electron of mass m and charge q is accelerated from rest in a uniform electric field of strength E. The velocity acquired by it as it travels a distance l is

(1) $\sqrt{\dfrac{2Eql}{m}}$ (2) $\sqrt{\dfrac{2Eq}{ml}}$

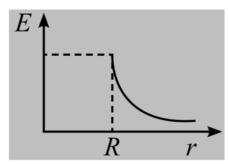
(3) $\sqrt{\dfrac{2Em}{ql}}$ (4) $\sqrt{\dfrac{Eq}{ml}}$

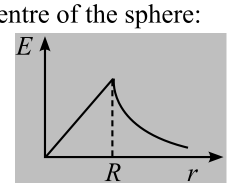
7. The figure shows some of the electric field lines corresponding to an electric field. The figure suggests

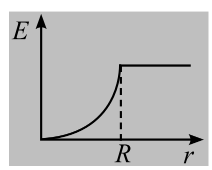


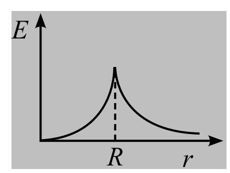
(1) $E_A > E_B > E_C$ (2) $E_A = E_B = E_C$
(3) $E_A = E_C > E_B$ (4) $E_A > E_C > E_B$

8. Which of the following graphs shows the variation of electric field E due to a hollow spherical conductor of radius R as a function of distance from the centre of the sphere:

(1) 

(2) 

(3) 

(4) 

9. In a region the intensity of an electric field is given by $\vec{E} = 2\hat{i} + 3\hat{j} + \hat{k}$ in NC^{-1}. The electric flux through a surface $\vec{S} = 10\hat{i}\ m^2$ in the region is:

(1) 5 Nm^2C^{-1} (2) 10 Nm^2C^{-1}
(3) 15 Nm^2C^{-1} (4) 20 Nm^2C^{-1}

10. A charged particle of charge q and mass m is released from rest in an uniform electric field E. Neglecting the effect of gravity, the kinetic energy of the charged particle after time 't' seconds is

(1) $\dfrac{Eqm}{t}$ (2) $\dfrac{E^2q^2t^2}{2m}$

(3) $\dfrac{2E^2t^2}{mq}$ (4) $\dfrac{Eq^2m}{2t^2}$

Parikshit Exercise-3 (Multiconcept)

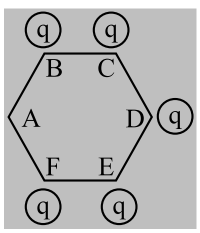
MATCH THE COLUMN MCQs

1. Match the entries of List-I with that of List-II:

List-I		List-II	
A.	Coulomb's law	P.	Total electric flux through a closed surface.
B.	Gauss's law	Q.	Vector sum of forces.
C.	Principle of superposition	R.	Force is inversely proportional to square of distance
D.	Quantization of charge	S.	Discrete nature of charge

(1) A-(Q); B-(R); C-(P); D-(S)
(2) A-(R); B-(P); C-(Q); D-(S)
(3) A-(P); B-(S); C-(R); D-(Q)
(4) A-(P); B-(Q); C-(R); D-(S)

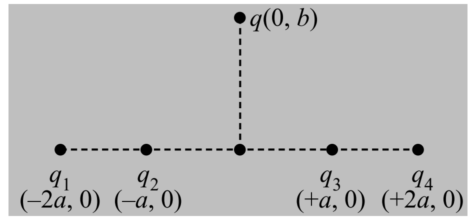
2. Five identical charges are kept at five vertices of a regular hexagon. Match the following two columns at centre of the hexagon. If in the given situation electric field at centre is E. Then,



Column-I		Column-II	
A.	If charge at B is removed, then electric field will become	P.	$2E$
B.	If charge at C is removed, then electric field will become	Q.	E
C.	If charge at D is removed then electric field will become	R.	zero
D.	If charges at B and C both are removed, then electric field will become	S.	$\sqrt{3}E$

(1) A-(S); B-(P); C-(R); D-(Q)
(2) A-(P); B-(S); C-(R); D-(Q)
(3) A-(Q); B-(R); C-(Q); D-(S)
(4) A-(S); B-(Q); C-(R); D-(P)

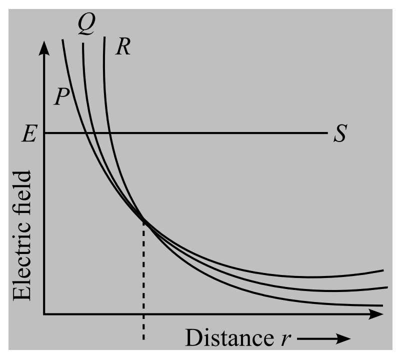
3. Four charges q_1, q_2, q_3 and q_4 of same magnitude are fixed along the x axis at $x = -2a, -a, +a$ and $+2a$, respectively. A positive charge q is placed on the positive y axis at a distance $b > 0$. Four options of the signs of these charges are given in Column-I. The direction of the forces on the charge q is given in Column-II. Match Column-I with Column-II and select the correct answer using the code given below the lists.



Column-I		Column-II	
A.	q_1, q_2, q_3, q_4 all positive	P.	$+x$
B.	q_1, q_2 positive and q_3, q_4 negative	Q.	$-x$
C.	q_1, q_4 positive and q_2, q_3 negative	R.	$+y$
D.	q_1, q_2, q_3, q_4 all are negative	S.	$-y$

(1) A-(R); B-(P); C-(S); D-(S)
(2) A-(P); B-(S); C-(R); D-(Q)
(3) A-(R); B-(Q); C-(P); D-(S)
(4) A-(S); B-(R); C-(Q); D-(P)

4. The curves in the graph show the variation of electric field E with distance r for various kinds of charge distributions given in List-I. Match them with their correct curves in List-II.



List-I		List-II	
A.	Electric field of a point sized dipole.	P.	P
B.	Electric field due to an infinitely long straight uniformly charged wire.	Q.	Q
C.	Electric field due to a uniformly charged plane sheet.	R.	R
D.	Electric field due to a point charge.	S.	S

(1) A-(Q); B-(S); C-(R); D-(P)
(2) A-(S); B-(R); C-(Q); D-(P)
(3) A-(P); B-(Q); C-(R); D-(S)
(4) A-(R); B-(P); C-(S); D-(Q)

PYQ's Exercise-4 (Important NEET PYQ's)

1. An electric dipole is placed at an angle of 30° with an electric field of intensity 2×10^5 NC^{-1}. It experiences a torque equal to 4 Nm. Calculate the magnitude of charge on the dipole, if the dipole length is 2 cm. **(2023)**

(1) 2 mC (2) 6 mC

(3) 8 mC (4) 4 mC

2. If $\oint_s \vec{E} \cdot d\vec{S} = 0$ over a surface, then: **(2023)**

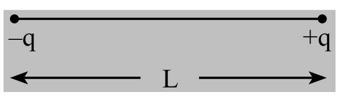
(1) The electric field inside the surface is necessarily uniform.

(2) The number of flux lines entering the surface must be equal to the number of flux lines leaving it.

(3) The magnitude of electric field on surface is constant.

(4) All the charges must necessarily be inside the surface.

3. Two point charges $-q$ and $+q$ are placed at a distance of L, as shown in the figure

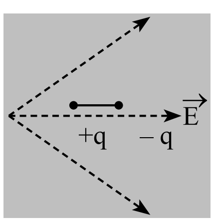


The magnitude of electric field intensity at a distance R ($R >> L$) varies as **(2022)**

(1) $\frac{1}{R^6}$ (2) $\frac{1}{R^2}$

(3) $\frac{1}{R^3}$ (4) $\frac{1}{R^4}$

4. A dipole is placed in an electric field as shown. In which direction will it move? **(2021)**



(1) Towards the right as its potential energy will decrease.

(2) Towards the left as its potential energy will decrease.

(3) Towards the right as its potential energy will increase.

(4) Towards the left as its potential energy will increase.

5. The electric field at a point on the equatorial plane at a distance r from the centre of a dipole having dipole moment $\vec{P}$ is given by,

(r >> separation of two charges forming the dipole, ϵ_0 – permitivity of free space) **(2020 Covid)**

(1) $\vec{E} = \frac{2\vec{P}}{4\pi \epsilon_0 r^3}$ (2) $\vec{E} = -\frac{2\vec{P}}{4\pi \epsilon_0 r^3}$

(3) $\vec{E} = -\frac{\vec{P}}{4\pi \epsilon_0 r^3}$ (4) $\vec{E} = \frac{\vec{P}}{4\pi \epsilon_0 r^3}$

6. A spherical conductor of radius 10 cm has a charge of 3.2×10^{-7} C distributed uniformly. What is the magnitude of electric field at a point 15 cm from the centre of the sphere?

$\left(\frac{1}{4\pi \epsilon_0} = 9 \times 10^9 \text{ N m}^2/\text{C}^2\right)$ **(2020)**

(1) 1.28×10^5 N/C (2) 1.28×10^6 N/C

(3) 1.28×10^7 N/C (4) 1.28×10^4 N/C

7. A hollow metal sphere of radius R is uniformly charged. The electric field due to the sphere at a distance r from the centre **(2019)**

(1) Increases as r increases for $r < R$ and for $r > R$

(2) Zero as r increases for $r < R$, decreases as r increases for $r > R$

(3) Zero as r increases for $r < R$, increases as r increases for $r > R$

(4) Decreases as r increases for $r < R$ and for $r > R$

8. Two parallel infinite line charges with linear charge densities $+\lambda$ C/m and $-\lambda$ C/m are placed at a distance of 2R in free space. What is the electric field mid-way between the two line charges? **(2019)**

(1) Zero (2) $\frac{2\lambda}{\pi\varepsilon_0 R}$ N / C

(3) $\frac{\lambda}{\pi\varepsilon_0 R}$ N / C (4) $\frac{\lambda}{2\pi\varepsilon_0 R}$ N / C

9. Two point charges A and B, having charges $+Q$ and $-Q$ respectively, are placed at certain distance apart and force acting between them is F. If 25% charge of A is transferred to B, then force between the charges becomes **(2019)**

(1) F (2) $\frac{9F}{16}$

(3) $\frac{16F}{9}$ (4) $\frac{4F}{3}$

10. Suppose the charge of a proton and an electron differ slightly. One of them is $-e$, the other is $(e + \Delta e)$. If the net of electrostatic force and gravitational force between two hydrogen atoms placed at a distance d (much greater than atomic size) apart is zero, then Δe is of the order of [Given mass of hydrogen $m_h = 1.67 \times 10^{-27}$ kg] **(2017-Delhi)**

(1) 10^{-23}C (2) 10^{-37}C

(3) 10^{-47}C (4) 10^{-20}C

11. Two identical charged spheres suspended from a common point by two massless strings of lengths l, are initially at a distance d ($d << l$) apart because of their mutual repulsion. The charges begin to leak from both the spheres at a constant rate. As a result, the spheres approach each other with a velocity V. Then V varies as a function of the distance x between the spheres, as **(2016-I)**

(1) $V \propto x^{\frac{1}{2}}$ (2) $V \propto x$ (3) $V \propto x^{-\frac{1}{2}}$ (4) $V \propto x^{-1}$

12. The electric field in a certain region is acting radially outward and is given by E = Ar. A charge contained in a sphere of radius 'a' centered at the origin of the field, will be given by **(2015)**

(1) $A\varepsilon_0 a^2$ (2) $4\pi\varepsilon_0 Aa^3$
(3) $\varepsilon_0 Aa^3$ (4) $4\pi\varepsilon_0 Aa^2$

ANSWER KEY

CONCEPT APPLICATION

1. (3) **2.** (3) **3.** (4) **4.** (4) **5.** (4) **6.** (4) **7.** (4) **8.** (4) **9.** (2) **10.** (3)
11. (2) **12.** (2) **13.** (2) **14.** (1) **15.** (1) **16.** (3) **17.** (3) **18.** (1) **19.** (3) **20.** (1)
21. (3) **22.** (3) **23.** (1) **24.** (2) **25.** (2) **26.** (3) **27.** (2)

BOARD LEVEL PROBLEMS

Multiple Choice Questions

1. (4) **2.** (2) **3.** (3) **4.** (2) **5.** (2) **6.** (4) **7.** (4) **8.** (3) **9.** (2) **10.** (4)

Assertion and Reason Questions

1. (1) **2.** (2) **3.** (1)

Case Based Study Type

1. (*i*)-(2), (*ii*)-(2) **2.** (*i*)-(1), (*ii*)-(1)

PRARAMBH EXERCISE-1 (TOPICWISE)

1. (2) **2.** (2) **3.** (4) **4.** (1) **5.** (1) **6.** (3) **7.** (1) **8.** (3) **9.** (1) **10.** (3)
11. (4) **12.** (4) **13.** (4) **14.** (4) **15.** (4) **16.** (4) **17.** (1) **18.** (4) **19.** (1) **20.** (2)
21. (2) **22.** (2) **23.** (3) **24.** (4) **25.** (1) **26.** (2) **27.** (1) **28.** (3) **29.** (4) **30.** (4)
31. (3) **32.** (3) **33.** (4) **34.** (1) **35.** (1) **36.** (2) **37.** (1) **38.** (1) **39.** (3) **40.** (1)
41. (2) **42.** (2) **43.** (2) **44.** (4) **45.** (4) **46.** (1) **47.** (3) **48.** (1) **49.** (4) **50.** (3)
51. (2) **52.** (1) **53.** (3) **54.** (4) **55.** (1) **56.** (4) **57.** (2) **58.** (3) **59.** (4) **60.** (3)
61. (1) **62.** (1) **63.** (4) **64.** (1)

PRABAL EXERCISE-2 (LEARNING PLUS)

1. (2) **2.** (2) **3.** (2) **4.** (1) **5.** (1) **6.** (1) **7.** (3) **8.** (1) **9.** (4) **10.** (2)
11. (1) **12.** (3) **13.** (4) **14.** (3) **15.** (1) **16.** (1) **17.** (2) **18.** (1) **19.** (1) **20.** (4)
21. (1) **22.** (2) **23.** (3) **24.** (3) **25.** (4) **26.** (4) **27.** (3) **28.** (2) **29.** (1) **30.** (3)
31. (3)

PARIKSHIT EXERCISE-3 (MULTICONCEPT)

1. (2) **2.** (4) **3.** (1) **4.** (4) **5.** (1) **6.** (4) **7.** (1) **8.** (4) **9.** (1) **10.** (1)
11. (4) **12.** (3) **13.** (1) **14.** (2) **15.** (1) **16.** (4) **17.** (1) **18.** (4) **19.** (3) **20.** (1)
21. (1) **22.** (1)

PYQ'S EXERCISE-4 (IMPORTANT NEET PYQ's)

1. (1) **2.** (2) **3.** (3) **4.** (1) **5.** (3) **6.** (1) **7.** (2) **8.** (3) **9.** (2) **10.** (2)
11. (3) **12.** (2)

PW VIDYAPEETH Is Now Present In 140+ Cities Across India

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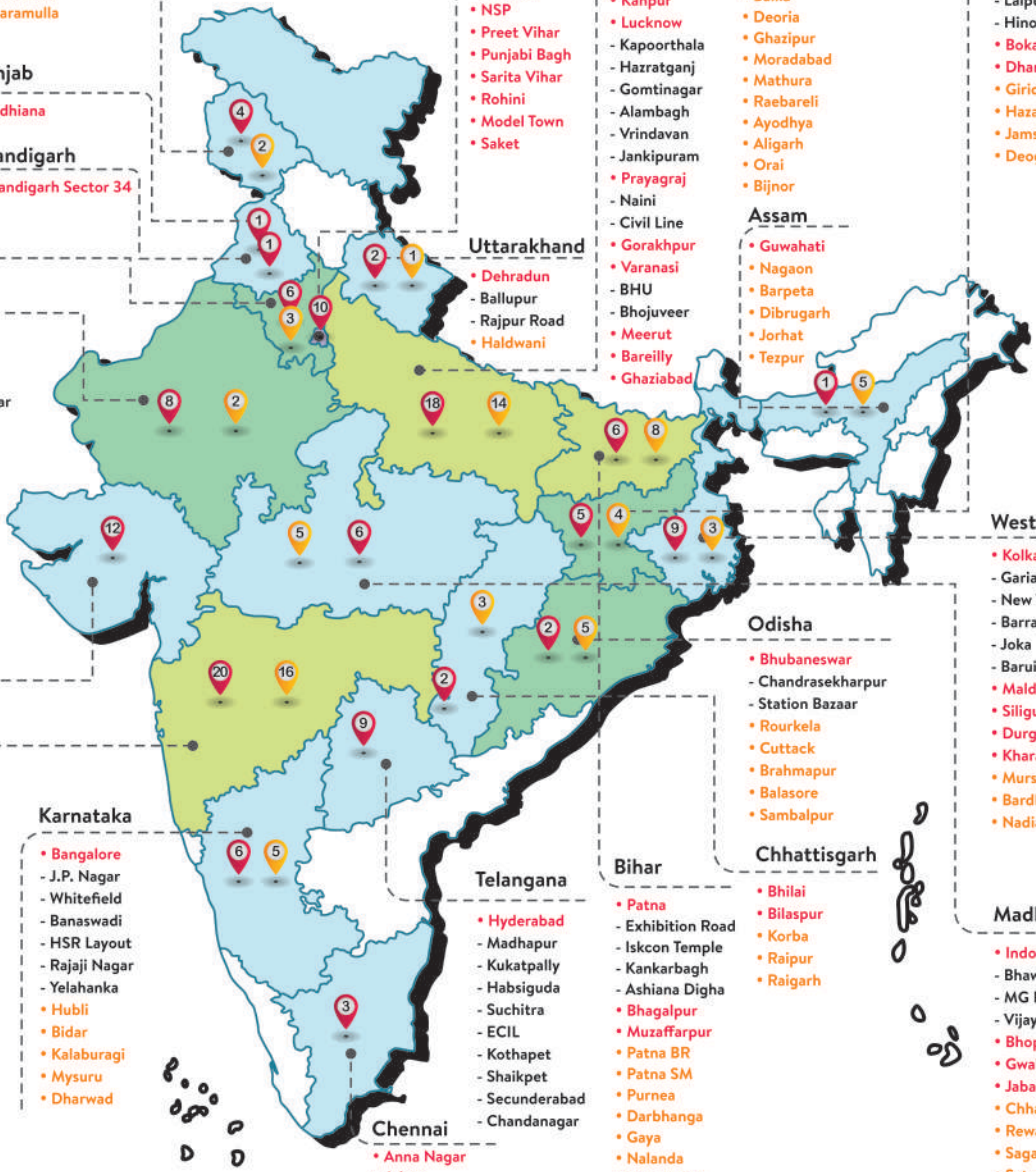

Jammu & Kashmir
- Srinagar
  - Rajbagh
  - Barzulla
- Jammu
  - Paloura
  - Channi Rama
- Anantnag
- Baramulla

Haryana
- Faridabad
- Panchkula
- Hisar
- Rohtak
- Gurugram
  - South City
  - Sector 16
- Narnaul
- Sonipat
- Sirsa

Punjab
- Ludhiana

Chandigarh
- Chandigarh Sector 34

Delhi
- Janakpuri
- Kalusarai
- Dwarka
- NSP
- Preet Vihar
- Punjabi Bagh
- Sarita Vihar
- Rohini
- Model Town
- Saket

Uttar Pradesh
- Noida
  - Block C
  - Gaur City
- Greater Noida
- Kanpur
- Lucknow
  - Kapoorthala
  - Hazratganj
  - Gomtinagar
  - Alambagh
  - Vrindavan
  - Jankipuram
- Prayagraj
  - Naini
  - Civil Line
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  - Bhojuveer
- Meerut
- Bareilly
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- Jhansi
- Jaunpur
- Ballia
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- Raebareli
- Ayodhya
- Aligarh
- Orai
- Bijnor

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  - Harmu
  - Lalpur
  - Hinoo
- Bokaro
- Dhanbad
- Giridih
- Hazaribagh
- Jamshedpur
- Deoghar

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- Dehradun
  - Ballupur
  - Rajpur Road
- Haldwani

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- Guwahati
- Nagaon
- Barpeta
- Dibrugarh
- Jorhat
- Tezpur

Gujarat
- Surat
  - Adajan
  - Vesu
- Bothra
  - Dahod
  - Satellite
- Bharuch
- Gandhinagar
- Ahmedabad
  - Satellite
  - Maninagar
  - Nikol
  - Gota
- Vadodara
  - Manjalpur
  - Vadiwadi

Rajasthan
- Jaipur
  - Tonk Road
  - RS Circle
  - Pratap Nagar
- Jodhpur
  - Akhaliya
  - Sardarpura
- Kota
- Udaipur
- Sikar
- Alwar
- Nagaur

West Bengal
- Kolkata
  - Gariahat
  - New Town
  - Barrackpore
  - Joka
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- Siliguri
- Durgapur
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- Brahmapur
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  - Banaswadi
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  - Yelahanka
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- Kalaburagi
- Mysuru
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  - Kukatpally
  - Habsiguda
  - Suchitra
  - ECIL
  - Kothapet
  - Shaikpet
  - Secunderabad
  - Chandanagar

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- Adyar
- Medvakkam

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  - Iskcon Temple
  - Kankarbagh
  - Ashiana Digha
- Bhagalpur
- Muzaffarpur
- Patna BR
- Patna SM
- Purnea
- Darbhanga
- Gaya
- Nalanda
- Samastipur
- Motihari

Chhattisgarh
- Bhilai
- Bilaspur
- Korba
- Raipur
- Raigarh

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- Indore
  - Bhawarkuan
  - MG Road
  - Vijay Nagar
- Bhopal
- Gwalior
- Jabalpur
- Chhatarpur
- Rewa
- Sagar
- Satna
- Chhindwara

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