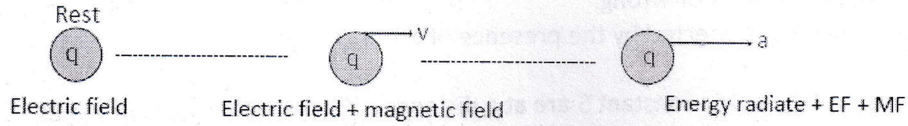
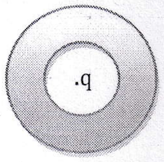
# [1] Electric Charge

Neutral —Change of electrons→ Charge

- 


- electron is the smallest charge hence charge associated mass
- any charge [Q = integer × e] known as quantization of charge.
- Charge is conserved
- Like charges repel and opposite charges attract.
- if we give charge to a conductor, whole charge will be distributed in outer most surface due to free electron




- when two conductors are connected then charge flow from one to another till same charge level, process is known as **conduction.** If both conductors are identical then they will have equal charge finally (Half of total charge).
- A charge may be a point charge, line charge, surface charge and volume charge according to the body which is to charge.

<u>Coulomb's law</u>

this law gives force between two <u>point charges</u>


(free space)

$$F = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r^2}$$ <u>along the joining line</u>

here $\varepsilon_0$→permittivity of free space = $8.86 \times 10^{-12}$ $C^2/N\text{-}m^2$

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

If medium b/w charge of dielectric constant K then permittivity of medium→ $\varepsilon = K\varepsilon_0$

hence $$F = \frac{1}{K\,4\pi\varepsilon_0}\frac{q_1 q_2}{r^2}$$

- Vector form: Force on $q_2$ due to $q_1$


$$\vec{F} = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r^2} \times \hat{r}$$

$$\vec{F} = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{|r|^3} \times \vec{r}$$

- force on any charge → <u>Draw FBD</u>

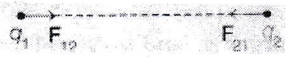
<u>**Assignment**</u>

**Q1:** An object has charge of 1C and gains $5.0 \times 10^{18}$ electrons. The net charge on the object becomes

(a) -0.80 C (b) + 0.80 C (c) + 1.80 C (d) + 0.20 C

**Q2:** A point charge is placed at the centre of a hollow conducting sphere of inner radius r and outer radius 2r. The ratio of the surface charge density of the inner surface to that of the outer surface will be............

**Q3:** According to Coulomb's law, which is the correct relation for the following figure

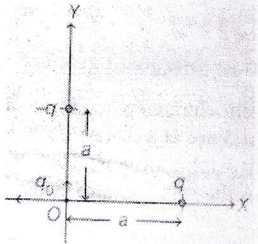



(a) $q_1q_2>0$ (b) $q_1q_2<0$ (c) $q_1q_2 = 0$ (d) $1> q_1q_2>0$

**Q4:** Point out whether the following statement is right or wrong.
The mutual forces between two charges do not get affected by the presence of other charges

**Q5:** Two point charges placed in a medium of dielectric constant 5 are at a distance r between them experience an electrostatic force F. The electrostatic force between them in vacuum at the same distance r will be
(a) 5F (b) F (c) F/2 (d) F/5

**Q6:** Three charges q, - q and $q_0$ are placed as shown in the figure. The magnitude of the net force on the charge $q_0$ at O is




# [2]Electric field

Neutral → Charge this charge creates **electric field** in the surrounding

- Electric field at any point due to positive charge is away from it while due to negative charge is towards it.
- if we release a positive charge in the electric field then it moves in the direction of electric field while negative charge moves opposite to direction of electric field.
- If a charge q is placed at a point at which electric field intensity E, it experiences a force **F = qE**

**Electric field due to various charge distribution**

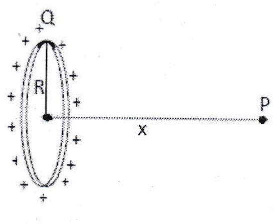
i.


$$|E_P| = \frac{1}{4\pi\varepsilon_0}\frac{q}{r^2}$$

$$\vec{E}_P = \frac{1}{4\pi\varepsilon_0}\frac{q}{|r|^3} \times \vec{r}$$

use when P and q have co-ordinate in 2D.....

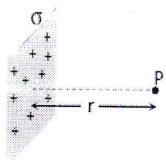
ii.




$$E_P = \frac{1}{4\pi\varepsilon_0}\frac{Qx}{(R^2+x^2)^{\frac{3}{2}}}$$ along the axis

- At center i.e. x = 0 → $E_c = 0$
- $E_{max}$ at $x = \frac{R}{\sqrt{2}}$

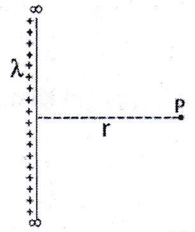
iii. Infinite plane sheet




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

uniform everywhere & perpendicular to the sheet

**iv.**




$E_P = K'\frac{2\lambda}{r}$

**v. Electric field due to spherical charge**

$E_P = K'\frac{q_{in}}{r^2}$

here r → CP

for $q_{in}$ imagine sphere of common center through point in mind

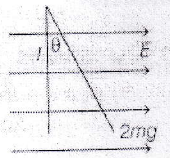
## Assignment

**Q1: Assertion:** A negative charge in an electric field moves along the direction of the electric field.

**Reason:** On a negative charge the force acts in the direction of the electric field.

**Q2:** An electron experiences a force ($1.6 \times 10^{-18}$ N) i in an electric field E. The electric field E is
(a) ($1{\times}10^3$ N/C)i (b) -($1{\times}10^3$ N/C)i (c) ($1{\times}10^{-3}$ N/C)i (c) -($1{\times}10^{-3}$ N/C)i

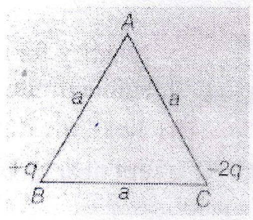
**Q3:** A small object with charge q and weight mg is attached to one end of a string of length L attached to a stationary support. The system is placed-in a uniform horizontal electric field E, as shown in the figure. In the presence of the field, the string makes a constant angle θ with the vertical. The sign and magnitude of q is.............




**Q4:** An isolated point charge particle produces an electric field E at a point 3 m away from it. The distance of the point at which the field is E/4 will be (a) 2m (b)3m (c) 4m (d) 6m

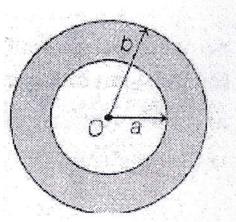
**Q5:** Two point charges +8q and - 2q are located at x= 0 and x = L respectively. The point on X-axis at which net electric field is zero due to these charges is (a) 8L (b) 4L (c) 2L (d) L

**Q6:** Two point charges + q and-2q are placed at the vertices B and C of an equilateral triangle ABC of side a as given in the figure. Obtain the expression for magnitude and the direction of the resultant electric field at the vertex A due to these two charges.




**Q7:** The magnitude of electric field due to a point charge 2q at distance r is E. Then, the magnitude of electric field due to a uniformly charged thin sphere shell of radius R with total charge q at a distance r/2 (r>> R) will be
(a)E/4 (b) 0 (c)2E (d)4E

**Q8:** A point charge + Q is placed at the centre O of an uncharged hollow spherical conductor of inner radius a and outer radius b. The magnitude of electric field vector at a distance (a) r = a/2 and (b) r =2b,from the centre of the shell



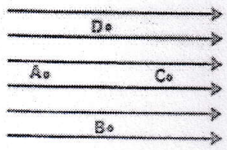

**Q9:** Two large charged plane sheets of charge densities σ and - 2σ are arranged vertically with a separation of d between them. Deduce expressions for the electric field at points (i) to the left of the first sheet (ii) to the right of the second sheet and (iii) between the two sheets.

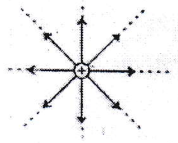
## Electric field Lines

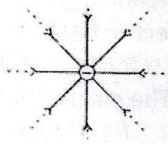
these are imaginary lines or curves which show the presence of electric field

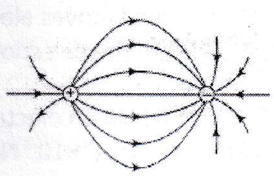
- Tangent to any point on electric field curves shows the direction of electric field at that point
- intersecting as well as touching lines are not exist because two tangents means two direction of electric field at that point.
- Electric field lines produced by static charges do not form close loop due to conservative nature.
- E.F.L. density (The Number of lines per unit area) ∝ electric field intensity

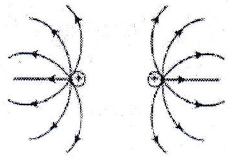
parallel equidistant electric field lines represent uniform electric field intensity



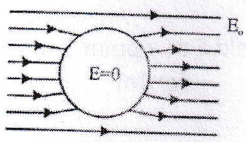






- Electric field lines are always perpendicular to equipotential surfaces E.g. conductor is a equipotential surface hence Electric field lines interact normally on the surface of the conductor

- if a conductor kept in external electric field, due to induction an anti-field is developed inside the conductor therefore the external EF is zero inside the conductor.




### Assignment

**Q1:** Why do the electrostatic field lines not form closed loop?

**Q2:** Why do the electric field lines never cross each other?

**Q3:** Draw the pattern of electric field lines due to an electric dipole.

**Q4:** Draw the pattern of electric field lines, when a point charge -Q is kept near an uncharged conducting plate.

**Q5:** A metallic sphere is placed in a uniform electric field as shown in the figure. Which path is followed by electric field lines and why?