Field Of Forces:

The electrostatic force is given as

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

The gravitational force is given as

$$F = G \frac{m_1 m_2}{r^2}$$

One may question (i) What are the origins of these forces? (ii) How are these forces transmitted from one mass to another or from one charge to another?

The answer to (i) is still unknown; the existence of these forces is accepted as it is that is why they are called basic forces of nature.

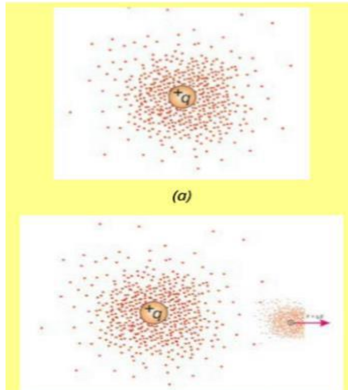
The answer to (ii) may be given by Michael Faraday's concept of electric field.

Electric Field:

It is an intrinsic property of nature and defines as it is the region around charged particle or charged body in which if another charge is placed, it experiences electrostatic force. According to Michael Faraday the presence of electric field cannot be tested until another charge q_0 is brought into the field of the charge q.

Test Charge:

The test charge q_0 should be very small so that it may not distort the field which has to be measured.



(a) Dots surrounding the positive charge indicate the presence of the electric field. The density of the dots is proportional to the strength of the electric field at different points, (b) Interaction of the field with the charge q_0

Electric Field Intensity:

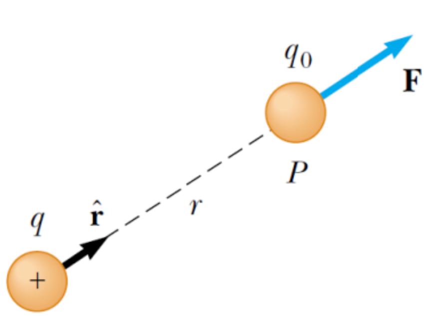
Electric field intensity at a point is equal to the electrostatic force experienced by a unit positive charge both in magnitude and direction.

If test charge q_0 is placed at a point in an electric field and experiences a force $\vec{F}$, the electric field intensity at that point is given by

$$\vec{E} = \frac{\vec{F}}{q_0}$$

Electric Field Intensity Due To Point Charge:

$$\vec{E} = \frac{\vec{F}}{q_0}$$



$$\vec{E} = \frac{1}{4\pi\varepsilon_0}\frac{qq_0}{r^2q_0}\hat{r}$$

$$\vec{E} = \frac{1}{4\pi\varepsilon_0} \frac{q}{r^2} \hat{r}$$ (In space)

$$\vec{E} = \frac{1}{4\pi\varepsilon_0 \varepsilon_r} \frac{q}{r^2} \hat{r}$$ (In the presence of any medium)

A point charge $q = -8.0 \times 10^{-8} C$ is placed at the origin. Calculate electric field at a point 2.0 m from the origin on the z-axis.

Given Data: Charge $q = -8.0 \times 10^{-8} C$, Distance $r = 2\ m$, Direction: z-axis $\hat{r} = \hat{k}$
To Determine: Electric Field $E = ?$
Calculations: $\vec{E} = k\frac{q}{r^2}\hat{k} = 9 \times 10^9 \times \frac{(-8.0 \times 10^{-8})}{(2)^2}\hat{k} = (-1.8 \times 10^2\ \hat{k}) NC^{-1}$

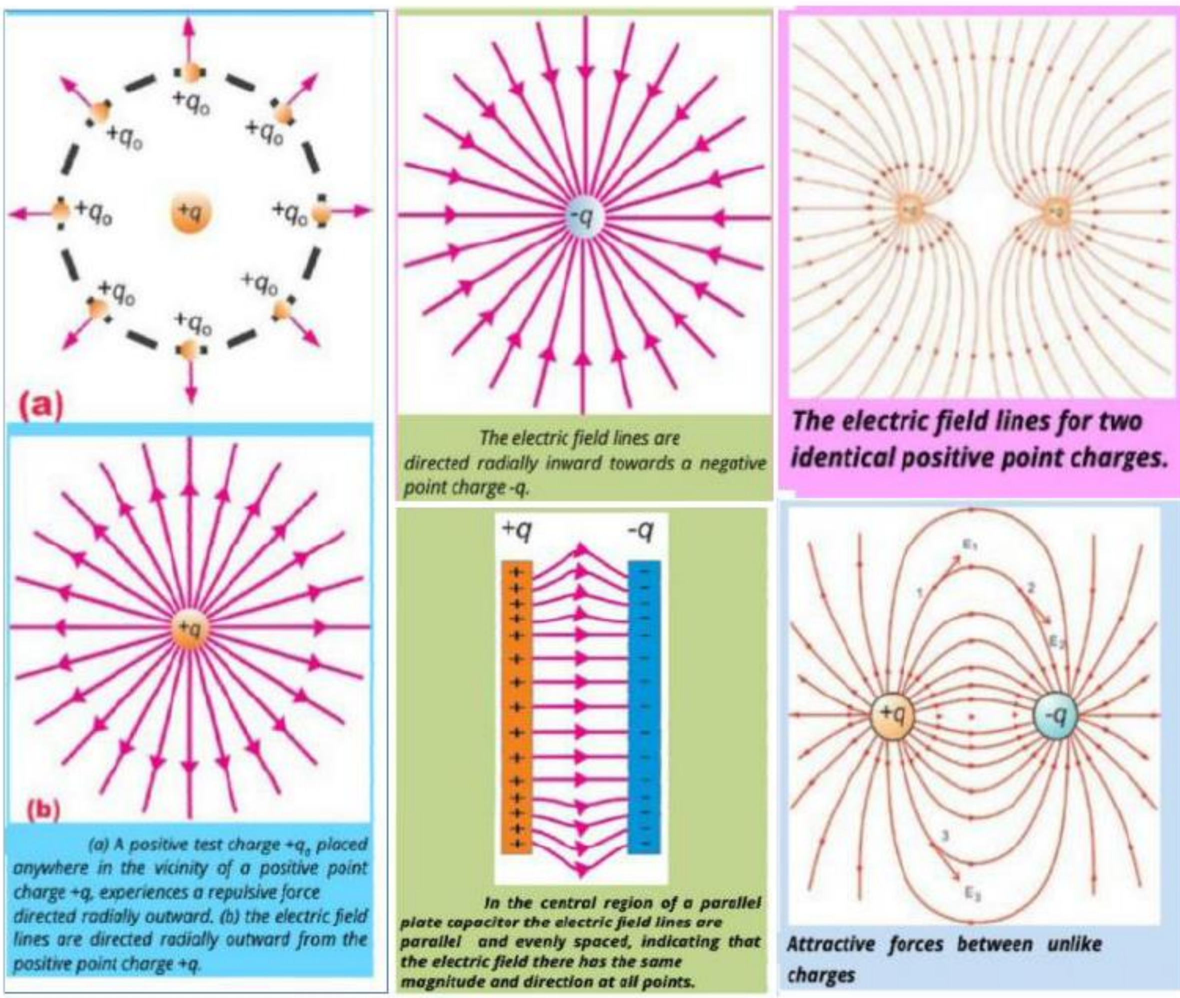
PROPERTIES OF ELECTRIC LINES OF FORCE

i) Electric field lines originate from positive charges and end on negative charges.

ii) The tangent to a field line at any point gives the direction of the electric field intensity at that point.

iii) The lines are closer where the field is strong, the lines are farther apart where the field is weak.

iv) No two lines cross each other.



(a) A positive test charge $+q_0$ placed anywhere in the vicinity of a positive point charge $+q$, experiences a repulsive force directed radially outward. (b) the electric field lines are directed radially outward from the positive point charge $+q$.

The electric field lines are directed radially inward towards a negative point charge $-q$.

In the central region of a parallel plate capacitor the electric field lines are parallel and evenly spaced, indicating that the electric field there has the same magnitude and direction at all points.

The electric field lines for two identical positive point charges.

Attractive forces between unlike charges

Electric field never ends.

A charge produces an electric field in space surrounding it in form of sphere (3D).

Uniform Field: Where the field lines are parallel and equally spaced the field is uniform.

Fringing Field: The bending of electric field lines near the edge of parallel plates