UNIT 8

ELECTRIC FIELDS

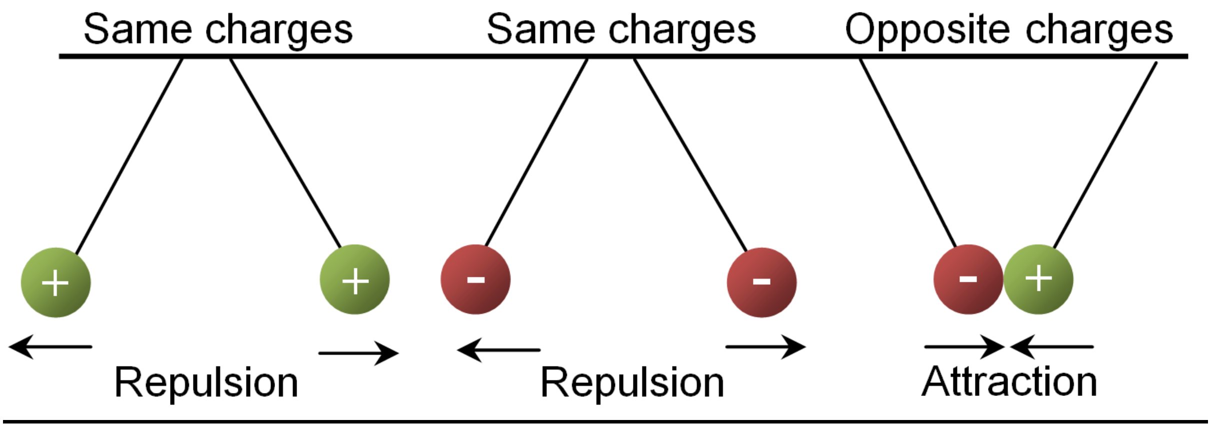
ELECTRIC CHARGE

Electric charge can be defined as a fundamental property of subatomic particles that gives rise to the phenomenon of experiencing force in the presence of electric and magnetic fields.

PROPERTIES OF CHARGES

*. There are two kinds of electric charge
- positive
- negative

* Fundamental characteristic of electric charges says like charges repel and unlike charges attract.



COULOMB'S LAW

In 1785, Charles Augustin de coulombs, a French physicist, investigated quantitatively the electrical attractions and repulsions between point charges.

Charles Coulomb measured the magnitudes of the electric forces between charged objects using the torsion balance, which he invented (Fig). The operating principle of the torsion balance is the same as that of the apparatus used by Cavendish to measure the gravitational constant , with the electrically neutral spheres replaced by charged ones. The electric force between charged spheres A and B in Figure causes the spheres to either attract or repel each other, and the resulting motion causes the suspended fiber to twist. Because the restoring torque of the twisted fiber is proportional to the angle through which the fiber rotates, a measurement of this angle

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provides a quantitative measure of the electric force of attraction or repulsion. Once the spheres are charged by rubbing, the electric force between them is very large compared with the gravitational attraction, and so the gravitational force can be neglected From Coulomb's experiments, we can generalize the properties of the **electric force** between two stationary charged particles.

STATEMENT:

The electrical force between two static point charges is directly proportional to the product of the magnitude of changes and inversely proportional to the square of their separation.

MATHEMATICAL FORM:

Let q_1 and q_2 be static point charges, at a distance 'r' apart from each other. The magnitude of the electrical force between them will be

$$F \ \alpha \ \frac{q_1 \ q_2}{r^2}$$

or

$$F = k \ \frac{q_1 \ q_2}{r^2}$$

In this expression, the proportionality constant k has the value

$K = 8.99 \times 10^9 \ N.m^2/C^2$

CONSTANT OF PROPORTIONALITY:

In above equations, K is a constant of proportionality and its value depends on the medium between the charges.

'K' FOR FREE SPACE:

To simplify the formulas of electromagnetism that are used more often than Coulombs, the constant 'K' is expressed as

$$K = \frac{1}{4\pi\epsilon_o}$$

Where ϵ_o is called the **permittivity** of free space. Its value is

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

The constant 'K' has the corresponding value

$$K = \frac{1}{4\pi\epsilon_o} = 9 \times 10^9 \ N. \ m^2/C^2$$

With this choice of the constant 'K',. Coulomb's law can be written as

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

COULOMB FORCE IN DIFFERENT MEDIUM :

The value of "K" for a medium other than free space is less and it is written as

$$K = \frac{1}{4\pi\epsilon_o\epsilon_r}$$

But $\epsilon_o\epsilon_r = \epsilon$

where $\epsilon_r = \frac{\epsilon}{\epsilon_o}$

Therefore

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

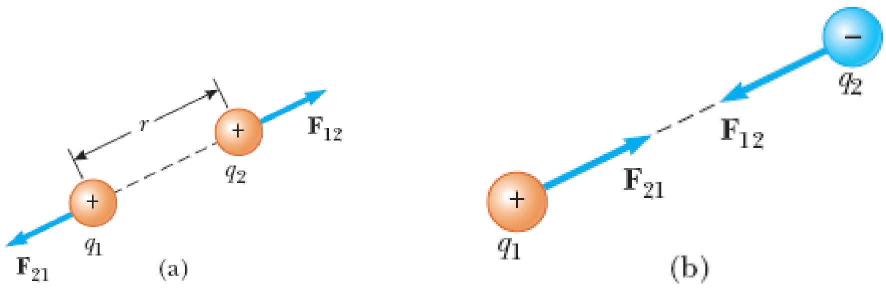
Dielectric constants for various materials at 25°C

Material	Dielectric constant κ
Vacuum	1.0
Air at 1.0 atm	1.0005
Polystyrene	2.6
Paper	3.5
Pyrex glass	4.7
Porcelain	6.5
Nerve membrane	7.0
Silicon	12.0
Ethanol	25.0
Water	78.5

Here ϵ is called absolute permittivity of the medium and ϵ_r is relative permittivity of the medium.

VECTOR FORM OF COULOMB'S LAW

The direction of the force in coulomb's law is along the line connecting the two charges. We know that like charges repel and opposite charges attract. This property is illustrated in the following figures, where force vector are shown for charges of various signs.



The electric force F_{12} exerted by a charge q_1 on other charge q_2 is written as

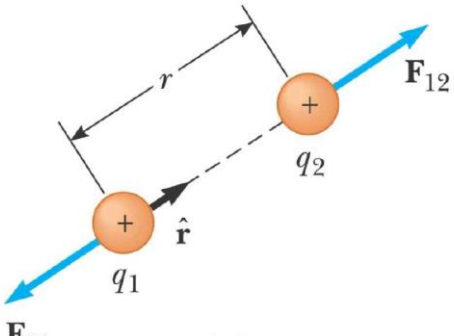
$$\vec{F}_{12} = \frac{1}{4\pi\epsilon}\frac{q_1 q_2}{r^2}\;\hat{r}_{12}$$

Where $\hat{r}_{12}$ is a unit vector directed from q_1 towards q_2 as shown in the figure

Similarly, an electric force F_{21} exerted by a charge q_2 on another charge q_1 is written as

$$\vec{F}_{21} = \frac{1}{4\pi\epsilon}\frac{q_1 q_2}{r^2}\;\hat{r}_{21}$$

Where $\hat{r}_{21}$ is a unit vector directed from q_2 towards q_1 as shown in the figure



(a)

Finally, Newton's third law of applies to each case shown in the figures. For example, the force exerted on charge 1 by charge 2 , F_{12}, is always equal in magnitude and opposite in direction to the force exerted on charge 2 by charge 1, F_{21},; that is,

$$\vec{F}_{12} = -\vec{F}_{12}$$

ELECTRIC FIELD

Faraday proposed that the force between two separated charges is transmitted through intervening space between them called electric field.

An electric field is a space or region around a charge where another electric charge experiences an electric force

ELECTRIC LINES OF FORCE

Michael Faraday was the first to introduce a visual representation of the electric force of field. Using lines of forces.

DEFINITION:

An electric line of force is a continuous line or curve drawn in an electric field such that tangent to it at any point gives the direction of the electric field at that point.

STRENGTH OF ELECTRIC FIELD

DEFINITION:

If a test charge q_o experiences a force **F** at the given location, the electric field at that location is

$$E = \frac{F}{q_o}$$

where q_0 = test charge (A test charge is a charge that doesn't affect the other charges that set up the field.)

F = force experienced by 'q_0'

E = electric field intensity at a point

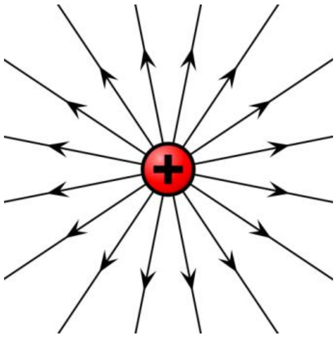
In vector form it is written as

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

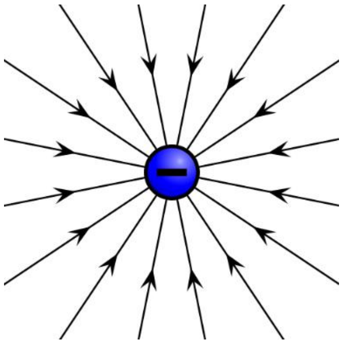
DIRECTION :

Electric field intensity is a vector quantity.

(i) AWAY FROM q, If q POSITIVE



(ii) **TOWARD q, If q NEGATIVE**.

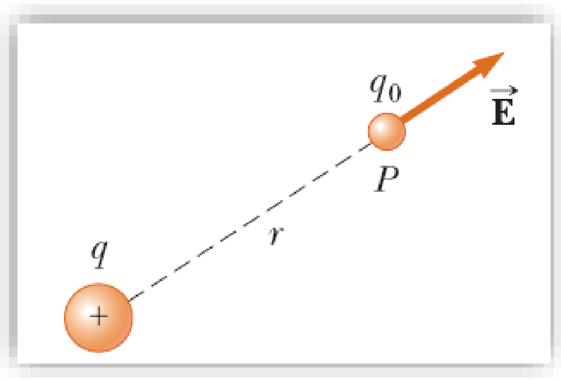


UNIT :

SI unit of electric field intensity is Newton per coulomb (N/C) or (NC^{-1})
Its another unit is volt per metre (V/m) or (Vm^{-1}).

ELECRIC FIELD INTENSITY NEAR AN ISOLATED POINT CHARGE

Consider a point 'P' in the field of charge 'q' at a distance 'r' from it. The force experienced by a test charge 'q_o' at point 'p' is given by



$$F = k\frac{q\ q_o}{r^2} \qquad \text{\_\_\_\_\_\_\_(i)}$$

applying our definition of the electric field , the magnitude of the field is

$$E = \frac{F}{q_o} \qquad \text{\_\_\_\_\_\_\_} \qquad \text{(ii)}$$

substitute the magnitude of F from equation (i) in equation (ii), we get

$$E = \frac{k\ q\ q_0}{r^2}\ x\ \frac{1}{q_0}$$

$$E = k\frac{q}{r^2}$$

the constant 'K' is expressed as

$$K = \frac{1}{4\pi\epsilon_o}$$

Where ϵ_o is called the **permittivity** of free space

$$E = \frac{1}{4\pi\epsilon_o} \quad \frac{q}{r^2}$$

If there are n number of charged particles q_1 , q_2 , q_3 , ……….. q_n
Then the net electric force of these charges at point. According to the superposition of principle,

$$\vec{F} = \vec{F_1} + \vec{F_2} + \vec{F_3} + \ldots\ldots\ldots\ldots. + \vec{F_n}$$

The net electric field of these charge particles are given by

$$\vec{E} = \frac{\vec{F_1}}{q_0} + \frac{\vec{F_2}}{q_0} + \frac{\vec{F_3}}{q_0} + \ldots\ldots\ldots\ldots. + \frac{\vec{F_n}}{q_0}$$

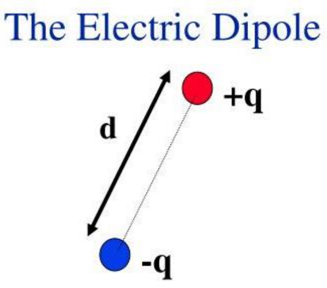
$$\vec{E} = \vec{E_1} + \vec{E_2} + \vec{E_3} + \ldots\ldots\ldots\ldots. + \vec{E_n}$$

Therefore, the electric field of these charges experienced by the test charge q_0 is the vector sum of the electric field of individual charges.

ELECTRIC DIPOLE

An electric dipole is a simple system in electromagnetism consisting of two opposite electric charges of equal magnitude, separated by a small distance d.

The two charges create an electric filed that has a distinct pattern, which field lines oriented along the axis of the dipole



An electric dipole consists of two equal and opposite charges (**q** and **-q**) separated a distance **d.**

DEFINE ELECTRIC DIPOLE MOMENT.

The dipole moment is defined as the product of the magnitude of one of the charges and the separation distance between the charges, multiplied by a unit vector pointing from the negative charge to the positive charge.

Mathematically, the electric dipole moment (p) is given by

$$\vec{P} = q\,\vec{d}$$

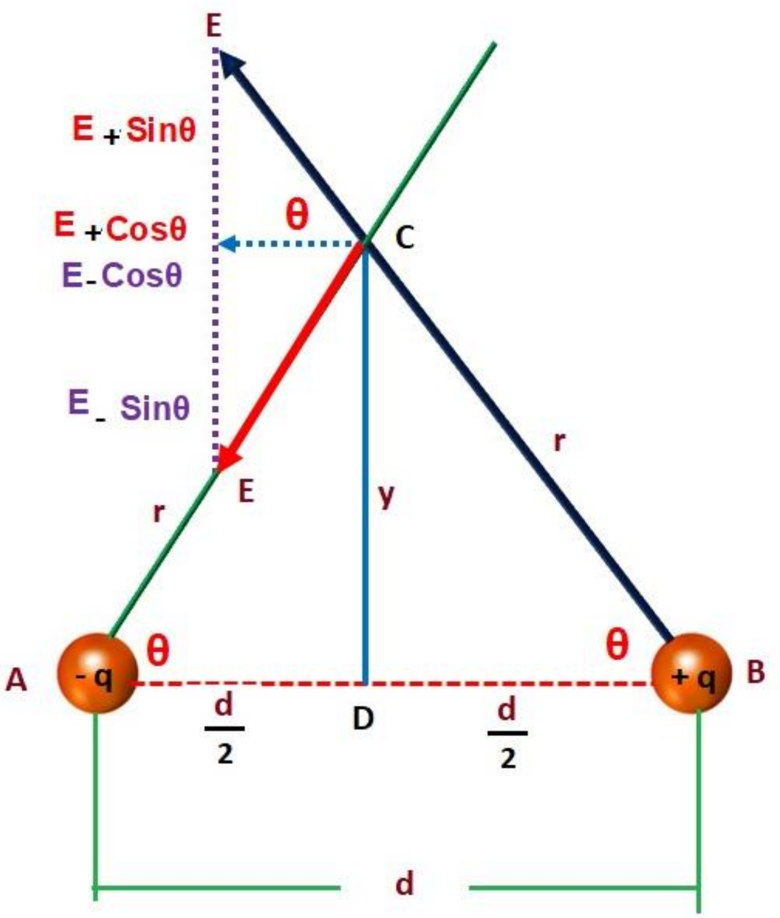
where q is the magnitude of the electric charge, and d is the distance between two charges. Dipole moment is a vector quantity.

UNIT

the SI unit of an electric dipole moment is Coulomb-meters (C m)

THE ELECTRIC FIELD DUE TO AN ELECTRIC DIPOLE

Consider two charges +q and –q placed at a small distance d form each other as shown in figure



We have to determine the electric field of the dipole at point C which is at a distance " y" from the centre of dipole.
The magnitude of the net electric field at point "C" is given by

$$E = E_{(+)} \, Cos\, \theta + E_{(-)} \, Cos\, \theta$$

$$E = \frac{1}{4\pi\epsilon_o} \frac{q}{r^2} \, Cos\, \theta + \frac{1}{4\pi\epsilon_o} \frac{q}{r^2} \, Cos\, \theta$$

$$E = 2 \frac{1}{4\pi\epsilon_o} \frac{q}{r^2} \, Cos\, \theta \ldots\ldots\ldots\ldots\ldots (i)$$

From figure, in triangle ADC

$$Cos\, \theta = \frac{\frac{d}{2}}{r}$$

$$Cos\, \theta = \frac{d}{2r}$$

Substituting the expression for Cosθ in equation (i), we get

$$E = 2 \frac{1}{4\pi\epsilon_o} \frac{q}{r^2} \frac{d}{2r}$$

$$E = \frac{1}{4\pi\epsilon_o} \frac{q\,d}{r^3} \quad \ldots\ldots\ldots\ldots (ii)$$

From figure, in triangle ADC

$$(hyp)^2 = (perp)^2 + (base)^2$$

$$r^2 = y^2 + \left(\frac{d}{2}\right)^2$$

$$r = \left[y^2 + \left(\frac{d}{2}\right)^2\right]^{\frac{1}{2}}$$

Substituting the expression for " r" in equation (ii)

$$E = \frac{1}{4\pi\epsilon_o} \frac{q\,d}{\left[y^2 + \left(\frac{d}{2}\right)^2\right]^{\frac{3}{2}}}$$

We are usually interested in the electrical effect of a dipole only at distances that are large compared with the dimensions of the dipole—that is, at distances such that $y \gg d$ .At such large distances, we can neglect the $\left(\frac{d}{2}\right)^2$ term in the denominator

$$E = \frac{1}{4\pi\,\epsilon_o} \frac{q\,d}{[y^2 + 0]^{\frac{3}{2}}}$$

$$E = \frac{1}{4\pi\,\epsilon_o} \frac{q\,d}{[y^2\,]^{\frac{3}{2}}}$$

$$E = \frac{1}{4\pi\,\epsilon_o} \frac{q\,d}{[y^2\,]^{\frac{3}{2}}}$$

$$E = \frac{1}{4\pi\,\epsilon_o} \frac{q\,d}{y^3}$$

The product *q d*, which involves the two intrinsic properties *q* and *d* of the dipole, is the magnitude *p* of a vector quantity known as the electric dipole moment $(P = q\ d)$

$$E = \frac{1}{4\pi\,\epsilon_o} \frac{P}{y^3}$$

The above Equation shows that we measure the electric field of a dipole only at distant points

ELECTRIC LINES OF FORCE

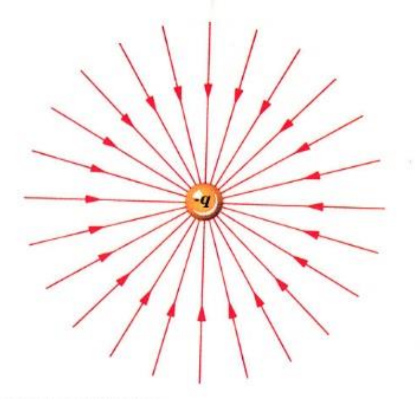
Michael Faraday was the first to introduce a visual representation of the electric force of a field. Using lines of forces.

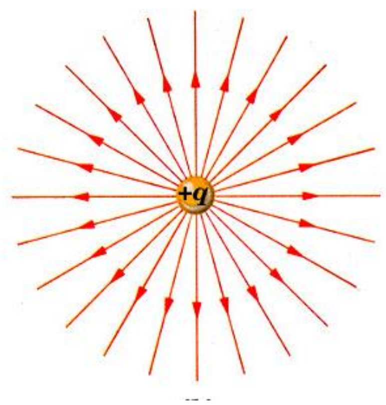
DEFINITION:

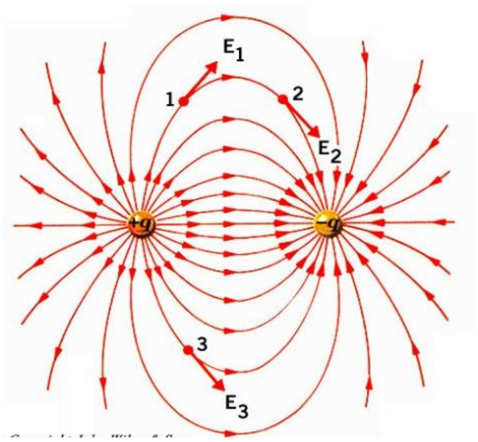
An electric line of force is a continuous line or curve drawn in electric field such that tangent to it at any point gives the direction of electric field at that point.

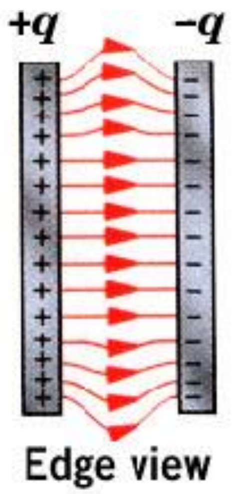
IMPORTANT FEATURES:

1. **Electric lines of force are imaginary lines.**
2. **These lines give the direction of the electric field at any point.**
3. **The lines of force ' flows ' radially outward from the positive charge and terminate on negative charges.**









4. **The density of lines(the number of lines per unit area placed perpendicular to the lines) at any point is proportional to the magnitude of electric field at that point.**
5 **Field lines do not cross**.

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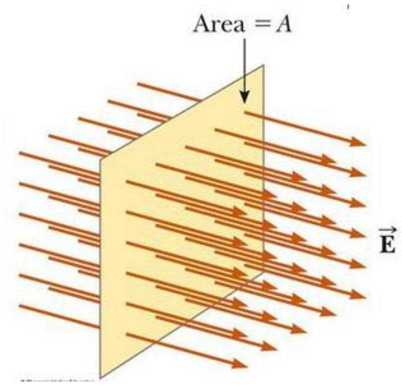
ELECTRIC FLUX

The word "flux" comes from a Latin word meaning "to flow", and its symbol is Φ (uppercase Greek phi).

DEFINITION-

Electric flux can be define as : total number of electric lines of force crossing a square area normally is called Electric flux.

$$\Delta\Phi = EA$$



If the area is not perpendicular to **E**,

DEFINITION-2

Electric flux also defines as the dot product of electric field and vector area.

Mathematically

$$\Phi = \vec{E} \cdot \vec{A}$$

$$\Phi = E\ A\ Cos\ \theta$$

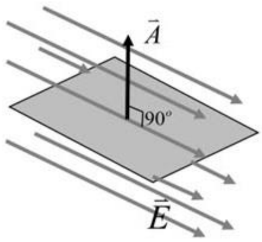
Flux is a scalar quantity.

UNIT:

SI unit of electric flux is $N.m^2/C$

SPECIAL CASES

MINIMUM FLUX



When $\theta = 90^o$ & $Cos 90^o = 0$

$\Phi = E\ A\cos\theta$

$= E\ A\ Cos 90$

$= E\ A(0)$

$\Phi = 0$

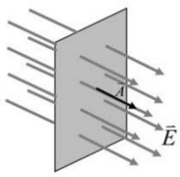
MAXIMUM FLUX

When $\theta = 0^o$ & $Cos 0^o = 1$

$\Phi = E\ A\cos\theta$

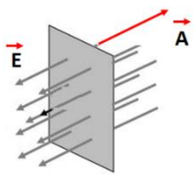
$\Phi = E\ A\ (1)$

$\Phi = E\ A$



Maximum number of lines will cross the area normally, hence maximum flux.

NEGATIVE FLUX



When $\theta > 90^o$ **for e.g** $\theta = 180^o$

$\Phi = E\ A\cos\theta$

$\Phi = E\ A\cos 180$

$\Phi = E\ A\ (-1)$

$\Phi = -E\ A$

<u>GAUSS' LAW</u>

This law was presented by a German mathematician "CARL FRIEDRICH GAUSS", which gives a relation between total flux through a closed surface and total change enclosed by the surface.

<u>STATEMENT:</u>

"The total flux through and closed surface is equal to $\frac{1}{\epsilon_o}$ times the total charge enclosed by the surface".

MATHEMATICAL PROOF:

(I) <u>FLUX THROUGH ARBITRARY SHAPE OBJECT DUE TO POINT CHARGE</u>

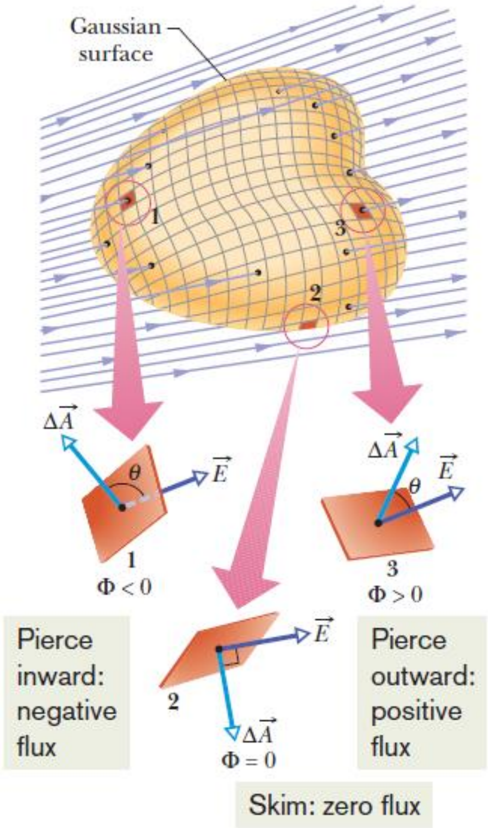
Consider a closed surface 's' of some arbitrary shape. Suppose it encloses a charge.

To calculate the flux through the surface, the whole surface is divided into small area elements i.e., $\Delta A_1, \Delta A_2, \ \Delta A_3 ...., \Delta A_N$

Hence the total flux 'through all these small area elements are

$\vec{E} \cdot \overrightarrow{\Delta A_1}, \ \vec{E} \cdot \overrightarrow{\Delta A_2}, \ \vec{E} \cdot \overrightarrow{\Delta A_3}, \qquad , \vec{E} \cdot \overrightarrow{\Delta A_N}$

The net electric flux through a closed surface is given as



$$\Delta\Phi = \Delta\Phi_1 + \Delta\Phi_2 + \Delta\Phi_3 + ... + \Delta\Phi_n$$

$$\Delta\Phi = \vec{E} \cdot \overrightarrow{\Delta A_1} + \vec{E} \cdot \overrightarrow{\Delta A_2} + \vec{E} \cdot \overrightarrow{\Delta A_3} + \cdots ... + \vec{E} \cdot \overrightarrow{\Delta A_N}$$

$$\Delta\Phi = \sum_{i=1}^{N} \vec{E} \cdot \overrightarrow{\Delta A_N}$$

<u>FLUX THROUGH SPHERE DUE TO POINT CHARGE AT CENTRE</u>

Consider a hollow sphere of radius 'r '. Let a positive point charge 'q' is placed at the center of a sphere .

To calculate the flux through the surface of a sphere, the whole surface, is divided in to small area elements i.e., $\Delta A_1, \Delta A_2 ....,\Delta A_n$

Now, flux through ΔA_1

$$\Phi_1 = \vec{E} \,.\, \overrightarrow{\Delta A_1}$$

$$\Phi_1 = E \ \Delta A_1 \text{ Cos } 0^o$$

$\Delta\Phi_1 = E\ \Delta A_1$

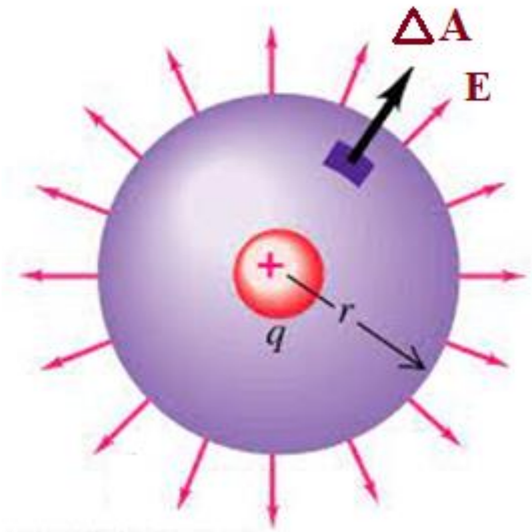
Flux through ΔA_2

$\Delta\Phi_2 = E\ \Delta A_2$

similarly Flux through ΔA_n

$\Delta\Phi_n = E\ \Delta A_n$

The total flux through the surface of the sphere will be the sum of all fluxes.



$$\Phi = \Delta\Phi_1 + \Delta\Phi_2 + \Delta\Phi_3 + \dots\dots\dots\dots + \Delta\Phi_n$$

$$= E\Delta A_1 + E\Delta A_2 + E\Delta A_3 + \dots\dots\dots + E\Delta A_n$$

$$= E(\Delta A_1 + \Delta A_2 + \dots\dots + \Delta A_n)$$

= E (surface area of sphere)

= E (4 π r ^{2})

$$= \frac{1}{4\pi \in_o}\frac{q}{r^2}(4\pi r^2) \qquad \because E = \frac{1}{4\pi \in_o}\frac{q}{r^2}$$

$$\phi = \frac{1}{\in_o}(q)$$

$$\phi = \frac{1}{\in_o}\ \textbf{(enclosed charge)}$$

POTENTIAL DIFFERENCE

DEFINITION :

The potential difference between two points in an electric field is defined as the amount of work done in moving a unit positive charge between two points against the electric field is called potential difference between these points. It is a scalar quantity.

$$\Delta V = \frac{W}{q}$$

Where W= work done

q = quantity of charge transferred

UNIT OF POTENTIAL DIFFERENCE

The SI unit of potential difference is volt (V).

DEFINITION OF VOLT

The potential difference between two points is said to be 1 volt if 1 joule of work is done in moving 1 coulomb of electric charge from one point to another.

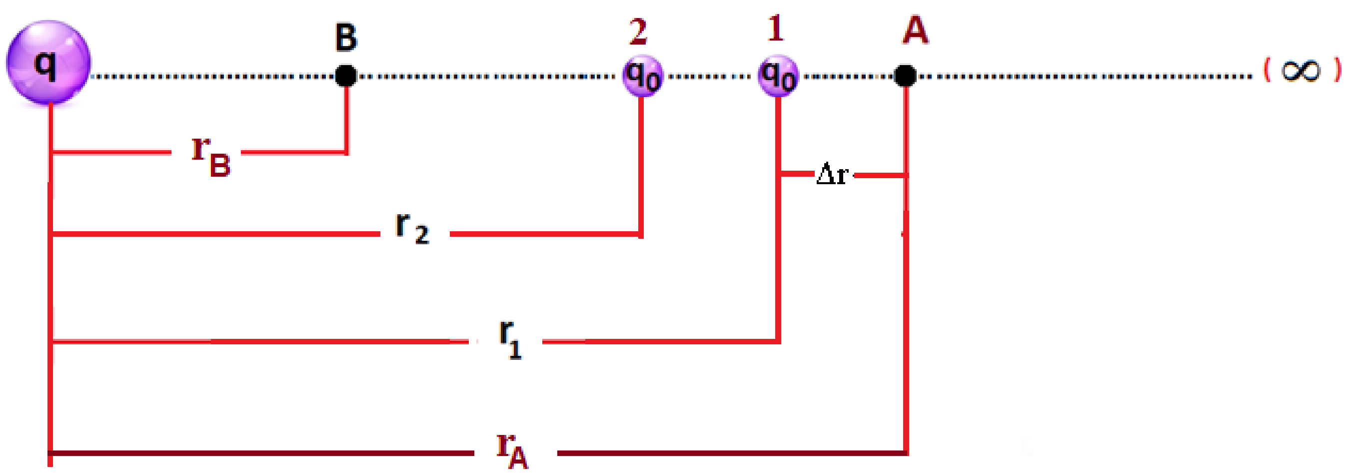
ABSOLUTE POTENTIAL

DEFINITION:

Work done in moving a unit positive charge from infinity (zero point) to a point in an electric field is called absolute potential at that point. It is a scalar quantity.

MATHEMATICAL EXPRESSION :

Consider a point charge q as a source charge. This charge creates an electric field at all points in space surrounding it. A test charge q_0 is placed at point A as shown in the figure.



Consider two points 'A' and 'B' in a straight lime which are far away from each other in an electric field. Let a charge q_o move from point 'A ' to 'B'.

Let distance from the source charge to position A = r_A
Let distance from the source charge to position 1 = r_1
Length of interval $\Delta r = r_A - r_1$
Distance from the middle of the interval r = $\sqrt{r_A . r_1}$

Work done of q_o from point 'A ' to 'B'

$$W = q_0\, E\, \Delta r Cos180^o$$
$$W = q_o E\, \Delta r(-1)$$
$$W = -q_o E\, \Delta r$$

Substituting E = K$\frac{q}{r^2}$ and $\Delta r = r_A - r_1$ in above equation.

$$W = -q_0\, \frac{K\,q}{r^2}(r_A - r_1)$$

Where 'r' is the mean of r_1 and r_A , which is equal to the geometric mean of r_1 and r_A , i.e.,

$$r = \sqrt{r_1 r_A}$$

$$\therefore W = -q_o K\frac{q}{(\sqrt{r_1 r_A})^2}(r_A - r_1)$$

$$W_{A\to 1} = -q_o\, k\, q\left(\frac{r_A - r_1}{r_1 r_A}\right)$$

$$W_{A\to 1} = -q_o k\, q\left(\frac{r_A}{r_A r_1} - \frac{r_1}{r_A r_1}\right)$$

$$W_{A\to 1} = -q_o k q\left(\frac{1}{r_1} - \frac{1}{r_A}\right)$$

But
(potential difference) = work done per unit charge

$$\Delta V = \frac{Total.Work}{Total.charge}$$

$$\Delta V = \frac{W_{A\to 1}}{q_o}$$

Substitute the value of $\Delta W_{A\to B}$ in above equation

$$\therefore \Delta V = -\frac{q_o k q\left(\frac{1}{r_1} - \frac{1}{r_A}\right)}{q_o}$$

$$\Delta V = -kq\left(\frac{1}{r_1} - \frac{1}{r_A}\right)$$

$$V_1 - V_A = -kq\left(\frac{1}{r_1} - \frac{1}{r_A}\right)$$

similarly

Work from A to B

$$V_B - V_A = -kq\left(\frac{1}{r_B} - \frac{1}{r_A}\right)$$

To find the absolute potential at point 'B' we consider point 'A'' at infinity i.e.,
$r_A = \infty$ and $V_1 = 0$

$$\therefore \frac{1}{r_A} = \frac{1}{\infty} = 0$$

Thus,

$$V_B - 0 = -kq\left(\frac{1}{r_B} - 0\right)$$

$$V_B = -\frac{1}{4\pi\epsilon_o}\left(\frac{q}{r_B}\right)$$

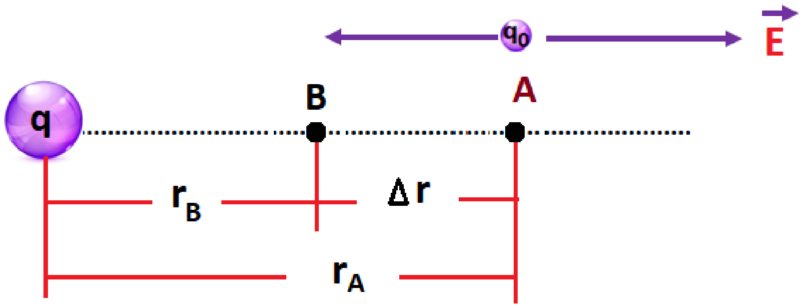
For any point in the field at a distance 'r' from 'q , we can write

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

This is the expression for absolute potential at a point in the electric field.

CALCULATING ELECTRIC FIELD FROM ELECTRIC POTENTIAL

Suppose that a positive test charge q_0 moves from one points A to another point B against the electric field. As shown in figure



The work done in moving a test through a distance Δr

Work done on q_o against the field = $-F \ \Delta r$

$$\Delta W = -q_o E \ \Delta S$$

potential difference between the points

$$\Delta V = \frac{\Delta W}{q_o}$$

$$\Delta V = -\frac{q_0 E \Delta S}{q_o}$$

$$\Delta V = -E \ \Delta S$$

or $$E = -\frac{\Delta V}{\Delta S}$$

$\left(\frac{\Delta V}{\Delta S}\right)$ is the ratio of change of potential with respect to the distance known as potential gradient.

The relation indicates that the electric field is equal to the negative rate of charge of potential with respect to distance which is also called the potential gradient.

$$E = -\text{grad}(V)$$

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SHORT REASONING QUESTIONS

QUESTION 1: Why do most objects tend to contain nearly equal numbers of positive and negative charges?

ANSWER: Most objects tend to contain nearly equal numbers of positive and negative charges because of the conservation of charge. This law of physics states that the total charge in an isolated system must remain constant.

QUESTION 2: When measuring an electric field, could we use a negative rather than a positive test charge?

ANSWER: We can use a negative test charge to measure an electric field. The direction of the electric field is always from positive to negative, so the force on a negative test charge will be in the opposite direction of the force on a positive test charge.

QUESTION 3: During fair weather, the electric field due to the net charge on Earth points downward. Is Earth charged positively or negatively?

ANSWER: The Earth is negatively charged during fair weather. This is because the Earth's atmosphere is constantly bombarded by solar radiation, which strips electrons from atoms in the atmosphere. These free electrons are then attracted to the Earth's surface, leaving the Earth with a net negative charge.
The electric field due to the Earth's net charge points downward because positive charges are attracted to negative charges. So, the negative charges on the Earth's surface repel the positive charges in the atmosphere, creating an electric field that points downward.

QUESTION 4: How the electric flux through a closed surface is independent on the size or shape of the surface enclosed the charge.

ANSWER: Gauss's law states that the electric flux through a closed surface is equal to the net charge enclosed by the surface divided by the permittivity of free space.

$$\Delta\phi_e = \vec{E}.\overrightarrow{\Delta A}$$

or

$$\Delta\phi_e = E\Delta A\cos\theta$$

QUESTION 5: What is electric dipole and electric dipole moment?

ANSWER: ELECTRIC DIPOLE
A dipole is a separation of opposite electrical charges and it is quantified by an electric dipole moment.

The **electric dipole moment** associated with two equal charges of opposite polarity separated by a distance, d is defined as the vector quantity having a magnitude equal to the product of the charge and the distance between the charges and having a direction from the negative to the positive charge along the line between the charges.

QUESTION 6: A charged particle is seen to be moving in an electric field along a straight line. How it effects the path of motion of the particle?

ANSWER: The path of motion of a charged particle in an electric field depends on the direction of the electric field and the charge of the particle. If the particle is positively charged, it will be attracted to the negative side of the electric field and repelled by the positive side. If the particle is negatively charged, it will be attracted to the positive side of the electric field and repelled by the negative side.
If the negative is moving in a straight line, it means that the electric field is uniform. This means that the force on the particle is constant and the particle will continue to move in a straight line until the force changes.

QUESTION 7: An electron has a speed of 10^6 m/s. Find its energy in electron volt.

ANSWER:
Data:

Speed of electron = $v = 10^6$ m/s
K.E = (in eV) = ?
$M = 9.11\times10^{-31}$ kg

Solution:

$K.E = 1/2\ mv^2$
$K.E = 1/2\ (9.11\times10^{-31})\ (10^6)^2$
$K.E = 4.55\times10^{-19}$

For eV:

$K.E = 4.55\times10^{-19} / 9.1\times10^{-19}$
$K.E = 0.5$ eV

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