Mon Tue Wed Thu Fri Sat

Date: ___/___/20___

-:(Applied Physics):-

Chapter # 01:-

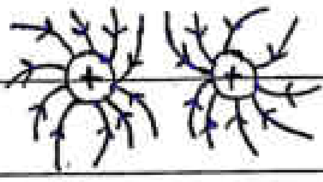
Qno1:-

Define the electric charge hence difference b/w conductor and insulator:-

Answer:-

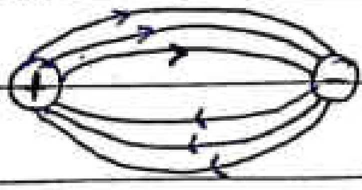
Electric Charge:-

- "The strength of (charge) electrical interaction of a particle with objects arounds it depends upon its electric charge."
- Charges with same sign repel each other.



(Repel)

- Charges with opposite sign always attract each other.



(Attraction)

Electrostatics:-

"The study of electric charges at rest under the action of electric force is called Electrostatics."

Types of Charges:-

The charge has two types called positive charge and negative charge.

- The similar (Like) charges repel each other with electric force.
- The unlike charges attract each other with electric force.

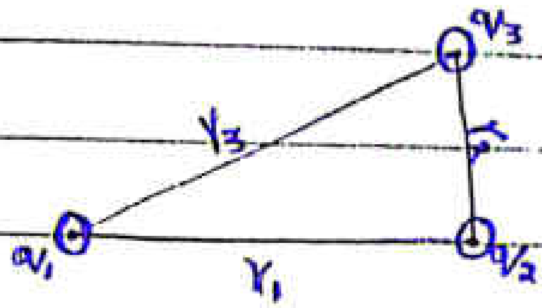
Explanation:-

If we have two point charges positive and negative, then the electric force by these charges is given by:

Date: ../../20..

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

Here the K is the constant of proportionality. The value of K is $9\times10^9 Nm^2C^{-2}$.



If we have 3rd point charges then the electric force produced by these 3 charges is given by.

$$F = K\frac{q_1 q_2}{r_1^2} + K\frac{q_2 q_3}{r_2^2} + K\frac{q_1 q_3}{r_3^2}$$

we know that

$$K = \frac{1}{4\pi\varepsilon_0}$$

But in case of 3 charges or more than two charges, The value of K is changed.

Date: __/__/20__

Mon Tue Wed Thu Fri Sat

Like:

$$K = \frac{1}{4\pi\varepsilon_0\varepsilon_1}$$

Then the force is given by:

$$F = \frac{1}{4\pi\varepsilon_1\varepsilon_0}\frac{q_1q_2}{r_1^2} + \frac{1}{4\pi\varepsilon_2\varepsilon_0}\frac{q_2q_3}{r_2^2} + \frac{1}{4\pi\varepsilon_0}\frac{q_1q_3}{r_3^2}$$

Conductor :-

The materials through which charges can flow easily are called conductors. Some properties of conductor are:

- The copper and aluminum are good examples of conductors.
- The resistivity of conductor is of the order of $10^{-8}\,\Omega^{-1}m$. ~~The~~
- The resistivity of Cu is $1.77 \times 10^{-8}\,\Omega^{-}m$.
- The conduction band and valence band overlaps in conductors so electrons can easily move.

Insulator:-

The materials through which charges cannot flow are called insulators.

Properties:-

- The electron are tightly bound in such materials.
- The well-Known insulators are glass and plastic.
- The insulator has only one conduction electron/cm^3.
- The resistivity of insulator is the order of 10^{11} to $10^{16}\,\Omega^{-1}m$. The resistivity of glass is $2\times10^{11}\,\Omega^{-1}m$.

Semiconductor:-

The partial conductors are called Semiconductors

Properties:-

- The well-Known semiconductors are silicon and germanium.
- A typical semiconductor has 10^{12} conduction electron/cm^3
- The resistivity of germanium is $0.5\,\Omega^{-1}m$.

(Applied Physics):-

Chapter # 01:-

Q No 2:-

Discuss Quantization of electric charge in detail?

Answer:-

Quantization of Charge:-

The electric Charge was thought to be a continuous fluid in Benjamin Franklin's day. Nowadays we Know that fluids such as air and water are not continous but are made of atoms and molecules.

Experiment shows that electrical fluid is also not continuous but is made up of multiples of a certain elementary charges. Any positive or negative charges 'q' can be written as:

$$q = ne$$

Mon Tue Wed Thu Fri Sat   Date: __/__/20__

where $n = \pm 1, \pm 2, \pm 3, \ldots\ldots$ and
$e = 1.6 \times 10^{-19} C$

Importance of 'e' :-

The elementary charge 'e' is one of the important constant of nature.
The electron and proton both have a charge of magnitude. The quarks ~~wil~~ which are consititueut particles of protons and neutrons have charges of $\pm \frac{e}{3}$ or $\pm \frac{2e}{3}$, but they cannot be detected individually.
That's why we do not take their charges to be the elementary charges.

Mon Tue Wed Thu Fri Sat Date: __/__/20__

Explanation:-

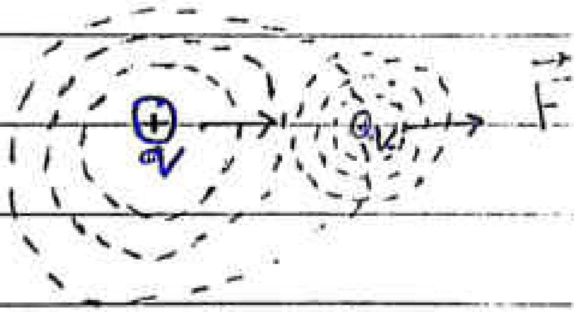
We say a physical quantity such as charge is quantized when it can have only discrete values rather than any value. For Example, it is possible to find a particle that have no charge at all or a charge of +10e or -6e but not a particle with a charge of say 3.57e.

The quantum of charges is small. For Example, in a ordinary 100 W light bulb about 10^{19} elementary charges enter the bulb every second and just as many leaves.

However, the graininess of electricity does not show up in such large-scale phenomenon just as you cannot feel the individual molecules of water with your hands.

Electric Field Intensity:-

The field intensity around a charge at a point P is defined as force per unit charge at that point.



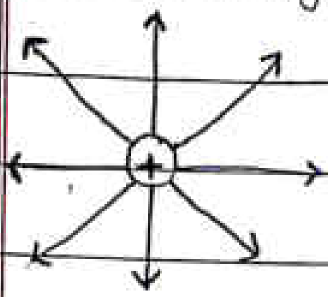
$$\vec{E} = \frac{\vec{F}}{q}$$

The unit of Electric Field Intensity is NC^{-1}. It is a vector Quantity.

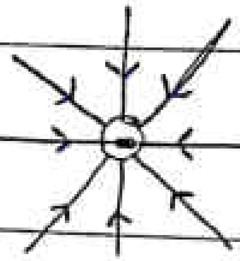
~~Elect~~

Electric Field Lines:-

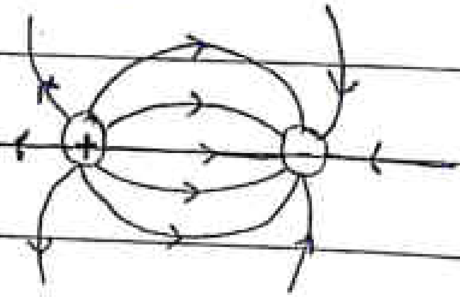
Michkel Faraday traced the electric field of a charge by using a test charge.
The field lines of positive and negative charges can be drawn as following:



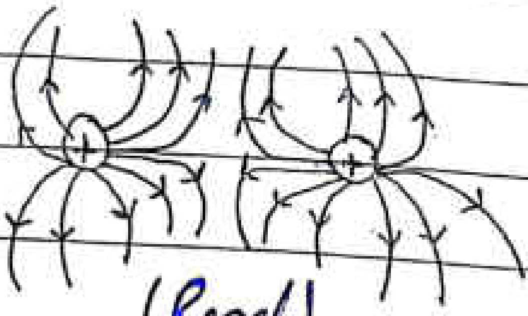
(Radialy Outward)



(Radialy Inward)



(Force of Attraction)



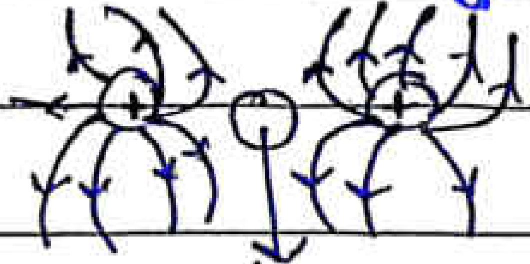
(Force of Repulsion)

(Repel)

Mon Tue Wed Thu Fri Sat

Date: __/__/20__

Field Free Region:-



(Free space Region)

In this Region no electric field lines exists.

:(Applied Physics):-

Chapter # 01:-

QNo3:-

Discuss law of conservation of electric charge in detail with Example?

Answer:-

Conservation of Charge:-

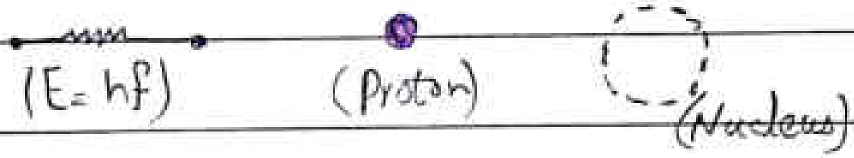
The positive charge appears on the rod when you rub a glass rod with silk. The measurements shows that negative charges of same magnitude appears on silk. This shows that rubbing does not create charge but only transfers it from one body to another body.

"According to law of conservation of electric charge the charges cannot be generate and cannot be destroyed it just transform

one object to another object."
This law of conservation of charge was first put forward by Benjamin Fraklin. Some Examples of charge conservation are:

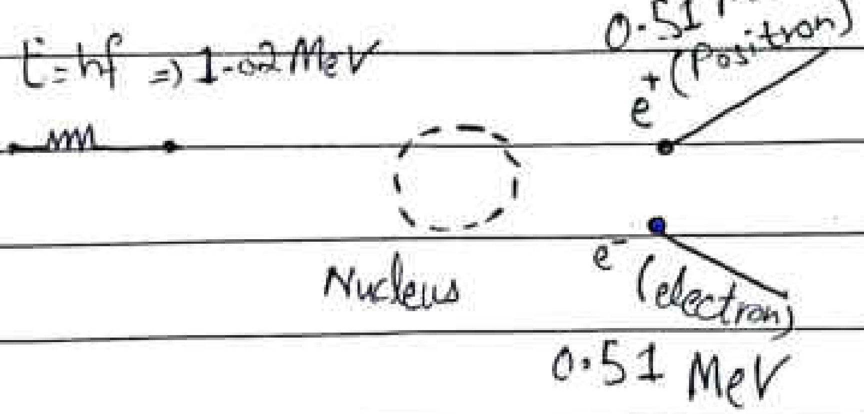
(i) Radioactive decay.
(ii) Pair Production.
(iii) Annihilation of Matter.

Pair Production:-



The charge is conserved in Pair Production. In this process the energy is transform into electron and positron.

Diagram:-

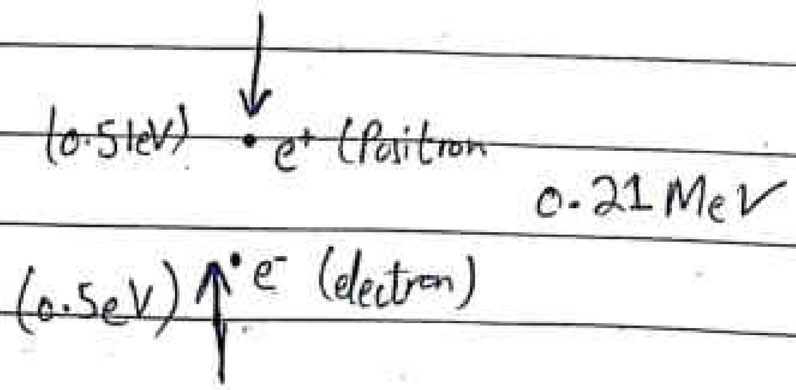


The net charge of the system is zero both before and after the event. Hence, The charge is conserved.

Annihilation of Matter:-

The charge conservation occurs in Annihilation process when an electron having a charge '-e' and its antiparticle called positron having charge '+e' annihilates in such a way that they transform into Energy.

Diagram :-



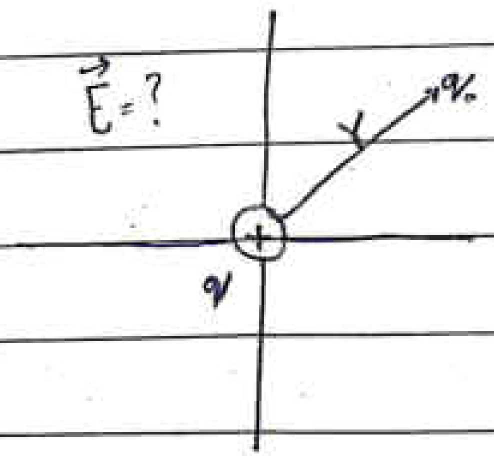
The annihilation process is the conserved process of pair production.

The net charge of the system is zero both before and after the event. Hence, The charge is conserved.

Q No 4:-
Explain Electric field at a point due to a point charge in detail?

Answer:-

Diagram:-



Let us make a diagram to electric field due to a point charge. (q).

Now take a test point charge

Mon Tue Wed Thu Fri Sat

Date: __/__/20

q_0 The distance of q_0 is 'r'

The force is given by the columb's law:

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

$$F = K \frac{q q_0}{r^2} \quad \text{(i)}$$

$$\boxed{\frac{F}{q_0} = \frac{Kq}{r^2}} \quad \text{(ii)}$$

we know that the expression of electric field intensity is:

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

So, eq. (ii) becomes

$$\boxed{E = \frac{Kq}{r^2}} \quad \text{Magnitude}$$

In vector Form:-

$$\vec{E} = \frac{Kq}{r^2} (\hat{r})$$

Q.4 State and explain Coulomb's law in detail?

COULOMB'S LAW

The electric force between two point charges is directly proportional to the product of the magnitudes of the charges and inversely proportional to the square of the distance between them.

EXPLANATION

Consider two point charges q_1 and q_2 separated by distance r. The magnitude of electric force F_e according to Coulomb's law is

$$F_e \propto q_1 q_2$$

$$F_e \propto \frac{1}{r^2}$$

On combing together

$$F_e \propto \frac{q_1 q_2}{r^2}$$

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

Where k is constant of proportionality and depends upon the nature of medium between charges and system of units used to measure force, charge and distance. If medium between charges is free space, value of k is written as

$$k = \frac{1}{4\pi\varepsilon_0} = 9 \times 10^9\ N - m^2/C^2$$

Where ε_0 is an electrical constant called permittivity of free space having value $8.85 \times 10^{-12}\ C^2/N{-}m^2$.

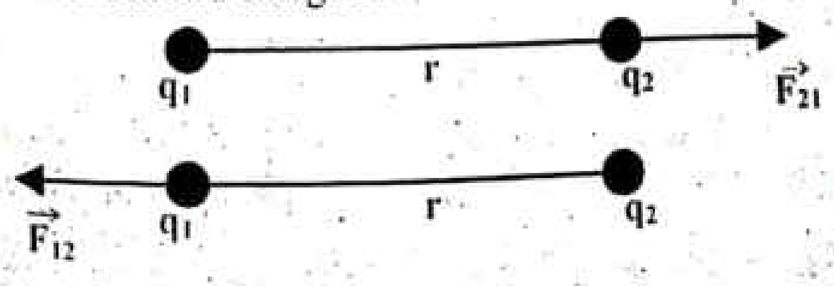
The Coulomb's force in free space is given as

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

The Coulomb's force is a mutual force. It means force $\vec{F}_{21}$ exerted by charge q_1 on charge q_2 is equal in magnitude but opposite in direction to force $\vec{F}_{12}$ exerted by charge q_2 on charge q_1

$$\vec{F}_{21} = -\vec{F}_{12}$$

The electric force between two charges in vector form is written as



$$\vec{F}_{21} = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r^2}\hat{r}_{21}$$

$$\vec{F}_{12} = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r^2}\hat{r}_{12}$$

EFFECT OF MEDIUM

The presence of a medium called dielectric between charges reduces the electric force between them as compared to the force in free space by certain factor that is constant for the given dielectric.

This constant is called relative permittivity and denoted by ε_r. The values of relative permittivity of different dielectrics are given in table.

Material	Vacuum	Air(1atm)	Ammonia (liquid)	Bakelite	Benzene	Germanium	Glass
ε_r	1	1.0006	22-25	5-16	2.284	16	4.8-10
Material	**Mica**	**Paraffined paper**	**Plexiglas**	**Rubber**	**Teflon**	**Transformer oil**	**Water (distilled)**
ε_r	3-7.5	2	3.40	2.94	2.1	2.1	78.5

The Coulomb's force in medium of relativity permittivity ε_r is given as

$$F_{med} = \frac{F_e}{\varepsilon_r} = \frac{1}{4\pi\varepsilon_0\,\varepsilon_r}\frac{q_1 q_2}{r^2}$$

USES OF VECTOR FORM OF COLULOMB'S LAW

The vector form has following uses:

1. It tells whether force is attractive or repulsive
2. The resultant force can be calculated from vector sum of forces when assembly of charges is under consideration.

ELECTRIC FORCE OF N–CHARGES

Consider assembly of n-charges. The total force exerted on charge "q" placed among n- point charges can be calculated by superposition principle as

$$\vec{F} = \vec{F}_1 + \vec{F}_2 + \vec{F}_3 + \ldots\ldots\ldots\ldots \vec{F}_n$$

$$\vec{F} = kq\sum_{i=1}^{n}\frac{q_i}{r_i^2}\hat{r}$$

Where $i = 1, 2, 3, 4, \text{-------} n$

Limitations

SIGNIFICANCE OF COULOMB'S LAW

The Coulomb's law describes completely how electrons are attracted by nucleus in atom, how atoms form molecules and how atoms and molecules develop into solids or liquids.

The Coulomb's law not only holds for macroscopic charged particles, it is equally applicable to microscopic particles like electron, proton. However, law is not applicable when charged particles move close to velocity of light and inside the nucleus under certain conditions because there exist nuclear force rather than Coulomb's force.

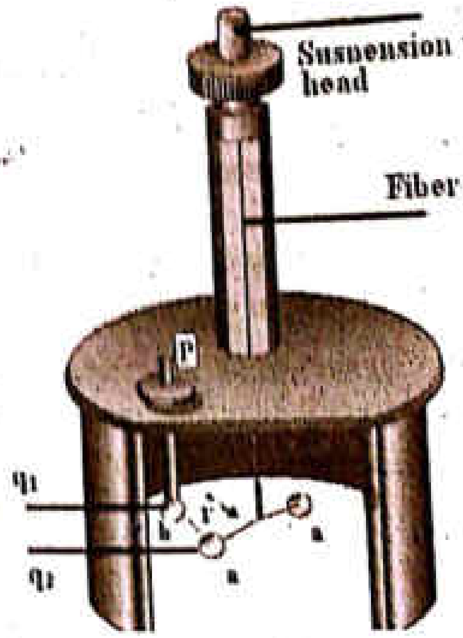
Q.5 Explain how Coulomb's law is verified experimentally ?

EXPERIMENTAL VERIFICATION

The charges of same polarity repel each other and charges of opposite polarity attract each other with a force called electrostatics force.

APPARATUS

Coulomb measured electric force between charges using apparatus called torsion balance. The torsion balance consists of horizontal rod carrying two metallic spheres a and a at its ends as shown in diagram.



The rod is suspended from the middle with a fiber. A small mirror M is attached to the fiber and beam of light reflected from mirror falls on the scale.

WORKING

An insulated rod P carrying a small charged sphere b equal in size to sphere a is brought near sphere a. Both spheres share charge $q_1 = q_2 = q$ when sphere b is touched with sphere a. The charge on sphere b can be further divided into q/2, q/4 by touching it with the spheres of equal sizes using same method.

By keeping the distance between sphere a and sphere b fixed, we find that twisting(electric force) in fiber is directly proportional to the magnitude of the charges on sphere a and sphere b.

The twisting(electric force) is found inversely proportional to square of the distance between the charged spheres by changing the distance between them.

SHORT QUESTIONS

Q1 The quantum of charge is 1.6×10^{-19} C. Is there a corresponding quantum of mass?

Ans: There is no quantum of mass.

Q2 What does it mean to say that a physical quantity is (a) quantized or (b) conserved. Give some examples.

Ans. CHARGE QUANTIZATION

When a physical quantity exists in discrete packets, it is called quantized.