IIT – DPP ON ELECTROSTATICS

ELECTRIC CHARGE

Electric charge, like mass, is one of the fundamental attributes of the particle of which the matter is composed of. Charge is the physical property of certain fundamental particles(like electron, proton) by virtue of which they interact with the other similar fundamental particle. To distinguish the nature of interaction, charges are divided into two parts (1) positive, and(2) negative. Like charges repel each other while unlike charges attract. SI unit of charge is coulomb and CGS unit is esu ($1C=3\times10^9$ esu).

Magnitude of the smallest known charges, which can exist free in the universe is e= $1.6\ 10^{-19}$C (charge of one electron or proton).

Charging of a Body

Charging can be done by two methods:

(1) Conduction, (2) Induction, and (3) Rubbing

Ordinarily, matter contains equal number of protons and electrons. A body can be charged by the transfer of electrons or redistribution of electrons.

The process of charging from an already charged body can happen either by conduction or induction. Conduction from a charged body involves transfer of like charges. A positively charged body can create more bodies which are positively charged but the sum of the total charge on all positively charged bodies will be the same as the earlier sum.

Induction is a process by which a charged body accomplishes the appearance of other charged bodies, without touching them or losing its own charge.

Basic Properties of Electric Charge

Quantization of charge

Charge exists in discrete packets rather than in continuous amount,ie. Charge on any body is the or integrals multiple of the charge of an electron.

- Q=+ngee, where n=0,1,2,….

Conservation of charge

Change is conserved, i.e.total charge on an isolated system is contant. By isolated system, we here mean a system through the boundary of which no charge is allowed to either escape or enter. This does not require that the amount of positive and negative charge are separately conserved. Only their algebraic sum is conserved.

Additivity

The total charge of the system is obtained by adding all the charges in system. The additive property of charge is due the fact that electrics charge has no direction associated with it,i.e.

charge is a scalar. Charge is not only scalar but it is also invariant for frames of reference in relative motion.

COULOMB'S LAW

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

In mathematical terms, the magnitude F of the force that each of two point charges q_1 and q_2, a distance r apart, exerts on the other can be expressed as

$F=k|q1q2|/r^2$

×

Where k is a proportionality constant whose numerical value depends on the system of units used.

In SI units,k=1/4 $=8.988\times10^9$ Nm^2/C^2 ·9 $\times10^9$ $Nm2/C^2$

Where is permittivity of free space.

The direction of the forces the two charge exert on each other always along the line joining them. When charges q1 and q2 have same sign, the forces are repulsive; when the charges have opposite signs the forces are attractive. The two forces obey Newtons third law. Coulomb force between two charges is a conservative force.

COULOMBS LAW IN VECTOR RELATIONS

Suppose two charges q_1 and q_2 are placed at point 1 and 2. The position vectors are r_1 and r_2, $r_{21}=r_2-r_1$. As per Coulombs law, the force on q_2 applied by q_1 will be

F_{21}

Where r^{21} is the unit vector in the direction from 1 to2.

Similarly, force on q_1 applied by q_2 is

F_{12}

Which is equal in magnitude and opposite in direction to the vector F_{21}

PRINCIPLE OF SUPERPOSITION

This principle states the interaction between any two charges is completely unaffected by the presence of the other.

In charges Q is placed in the vicinity of several charges q1,q2,……qn, then the force on