Answer on Question #42031 – Physics – Electromagnetism

Question.

1. Why electric field lines are normal to a conductor?

2. Why test charge can't be negative?

3. Define discrete charge.

4. Can charge be discontinuous?

5. Two identical particles each of mass M & charge Q are placed some distance apart. If they are in equilibrium under mutual gravitational & electric force then calculate the order of signature of charge Q/M in SI system.

Solution.

1. If the lines of the electric field will be directed at an angle to the metal surface, they can be decomposed into the longitudinal component and the perpendicular component. The longitudinal component will lead to an electric current. It changes the potentials on the surface of the conductor. But under normal conditions, the current in a charged piece of metal missing, there are not the potentials. Hence the lines of the electric field are perpendicular to the surface of conductor.

2. According to Coulomb's law:

$$\vec{F} = k\frac{Q_1 Q}{r^3}\vec{r}$$

$\vec{F}$ is the force with which one charge acts on other charge (test charge)
k is Coulomb's constant
Q_1 is a charge
Q is a test charge
r is a distance between charges

At the same time, the electric field is:

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

So, if we use a negative test charge, the direction of the field will be opposite to the direction of the force on that charge. With a positive test charge, the field and force are in the same direction.

3. The charges of particles are integer multiples of the elementary charge e; we say that electric charge is discrete (or quantized). Charge e is a charge of electron.

$$e = 1.6 \cdot 10^{-19}\ C$$

4. Charge is discrete and most elementary charge is the charge of electron e. Any charge is equal to the sum of the charges e. Therefore, we can say that there is the smallest charge e, then $2e$. So, charge $1.5e$ does not exist and charge less than e does not exist. Charge density also can be discontinuous, for example when electric field passes through the boundary of different surfaces.

5. Gravitational force is:

$$F_{grav} = G\frac{M^2}{r^2}$$

M is a mass of each particle

r is a distance between particles

$G = 6.67 \cdot 10^{-11}\ \frac{N \cdot m^2}{kg^2}$ is a gravitational constant

According to Coulomb's law electric force is:

$$F_{el} = k\frac{Q^2}{r^2}$$

$\vec{F}$ is the force with which one charge acts on other charge (test charge)

$k = 9 \cdot 10^9\ \frac{N \cdot m^2}{C^2}$ is Coulomb's constant

Q is a charge of each particle

r is a distance between charges

Particles are in equilibrium under mutual gravitational and electric forces, therefore:

$$F_{grav} = F_{el}$$

$$G\frac{M^2}{r^2} = k\frac{Q^2}{r^2}$$

So,

$$\frac{Q}{M} = \sqrt{\frac{G}{k}}$$

Calculate:

$$\frac{Q}{M} = \sqrt{\frac{6.67 \cdot 10^{-11}}{9 \cdot 10^9}} = 0.86 \cdot 10^{-10} \sim 10^{-10}\ \frac{C}{kg}$$

$$\frac{Q}{M} \sim 10^{-10}\ \frac{C}{kg}$$