1.Electric charge:

Charge is a fundamental property of the elementary particles that make up matter. The truth is that all matter is composed of protons, electrons, and neutrons. Two of these particles carry a charge (protons and electrons). From a macroscopic perspective, charge means the net charge or the excess charge. When we say that an object is charged, this means that the object has an excess charge resulting from either an excess number of electrons (negative charge) or an excess number of protons (positive charge). The truth is that charge is conserved and cannot be created or destroyed.

2.Coulomb Law:

The result of experimental measurements of the forces acting between electric charges is:

- There are only two types of electric charges: positive charges and negative charges.
- Two point charges exert a force on each other:

A - They act along a line The force between the two charges.

B- The magnitude of this force is directly proportional to the product of the two charges.

C- Its magnitude is inversely proportional to the square of the distance between them.

- The force acting between the two charges is either a repulsive force if the two charges are the same or an attractive force if the two charges are different.

The last two points (points 3 and 2) represent Coulomb's law: The electric force between two charges is directly proportional to the product of the two charges and inversely proportional to the square of the distance between them.

$$\vec{F}_{12} = K\frac{q_1 q_2}{|\vec{r}_{12}|^2}\hat{r}_{12} \dots\dots\dots\dots\dots\dots\dots\dots (1)$$

But $\hat{r}_{12} = \frac{\vec{r}_{12}}{|\vec{r}_{12}|}$

$$\vec{F}_{12} = \frac{1}{4\pi\epsilon_o}\frac{q_1 q_2}{||\vec{r}|_{12}|^3}\vec{r}_{12}$$

$$\epsilon_o = 8.85 \times 10^{-12}\frac{F}{m} or \frac{C^2}{J} or \frac{C^2}{N.m^2},\ and\ K = 9 \times 10^9 \frac{N.m^2}{coul^2}$$

Coulomb's law is used for point charges. A point charge, in the physical sense, is a charge whose dimensions are very small compared to any length. Coulomb's law applies to stable point charges in a vacuum, insulators, and conductors. Coulomb's law can also be applied to elementary charged particles (protons and electrons).

$$\vec{F}_{21} = K\frac{q_1 q_2}{|\vec{r}_{21}|^3}\hat{r}_{21}, \quad |\vec{F}_{21}| = |\vec{F}_{12}| \qquad but \quad \vec{F}_{12} = -\vec{F}_{21}$$

3.The Superposition Rule of Forces:

If there are more than two point charges, the forces between these charges can be determined by repeatedly using Equation.

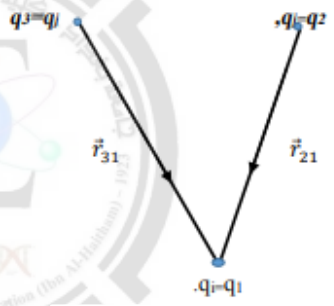
If we assume a system of N point charges, the forces acting on charge q_i are:

$$\vec{F}_i = \frac{1}{4\pi\epsilon_o} q_i \sum_{j\neq i}^{N} q_j \frac{\vec{r}_{ji}}{|\vec{r}_{ji}|^3}$$

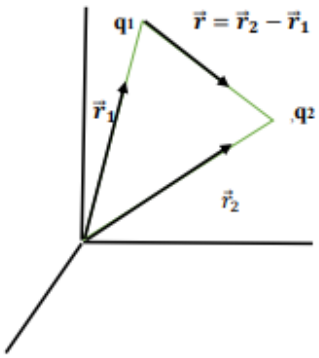
The addition sign (∑) indicates the fact that the vector sum includes all charges except the charge qi. This is the superposition rule of forces, which states that: The total forces acting on a body equal the vector sum of all forces acting on the body individually.

$$\vec{F} = \frac{1}{4\pi\epsilon_o}\frac{q_1 q_2}{|\vec{r}_{21}|^2}\hat{r}_{21} + \frac{1}{4\pi\,\epsilon_o}\frac{q_1 q_3}{|\vec{r}_{31}|^2}\hat{r}_{31} + \cdots \qquad as\ q_i = q_1, and\ q_j = q_2 \cdot q_3, \ldots\ldots$$

$$\vec{F} = K\frac{q_1 q_2}{|\vec{r}_{21}|^2}\hat{r}_{21} + K\frac{q_1 q_3}{|\vec{r}_{31}|^2}\hat{r}_{31}$$



. $\vec{r}_1 + \vec{r} = \vec{r}_2 \Rightarrow \vec{r} = \vec{r}_2 - \vec{r}_1$:



$$\vec{F} = K\frac{q_1 q_2}{|\vec{r}|^3}\vec{r} = \frac{1}{4\pi\epsilon_o}\frac{q_1 q_2(\vec{r}_2 - \vec{r}_1)}{|\vec{r}_2 - \vec{r}_1|^3} = \frac{q_1 q_2}{4\pi\epsilon_o}\frac{\left[\hat{i}(x_2 - x_1) + \hat{j}(y_2 - y_1) + \hat{k}(z_2 - z_1)\right]}{[(x_2 - x_1)^2 + (y_2 - y_1)^2 + (z_2 - z_1)^2]^{3/2}}$$

4.Charge density:

The idea of the interaction between N point charges can be extended to include the interaction between a point charge and a continuous (extended) charge distribution. The meaning of a continuous charge distribution: The electric charge consists of multiples of a basic charge, the electron charge ($1.6 \times 10^{-19} coul$), which is a very small amount. This means that the value of any electric charge must be equal to the electron charge multiplied by an integer. This, in turn, means that any small element of the volume taken from a charge distribution contains a very large number of electrons. It is then possible to describe any charge distribution in terms of a charge density function, which represents the maximum charge per unit volume when the charge size becomes infinitely small. The charge distribution can be described in terms of the following point functions:

Volumetric charge density function: The volumetric charge density is defined according to the relationship -1

$$\rho = \lim_{\Delta V \to 0} \frac{\Delta q}{\Delta V} = \frac{dq}{dV} \quad and\ dq = \rho dV, \therefore\ q = \int \rho dV$$

Surface charge density: The surface charge density is defined according to the relationship -2

$$\sigma = \lim_{\Delta S \to 0} \frac{\Delta q}{\Delta S} = \frac{dq}{dS} \quad and\ , dq = \sigma dS\ \therefore\ q = \int \sigma dS$$

Longitudinal charge density: The longitudinal charge density is defined according to the relationship -3

$$\lambda = \lim_{\Delta \ell \to 0} \frac{\Delta q}{\Delta \ell} = \frac{dq}{d\ell} \quad and\ ,\ dq = \lambda d\ell,\ q = \int \lambda d\ell$$

1. Charge is a fundamental property of:

A. Light waves

B. Elementary particles

C. Thermal energy

D. Gravity

2. The particles that carry electric charge among atomic components are:

A. Protons and neutrons

B. Electrons and neutrons

C. Protons and electrons

D. All of them

3. When we say a body is charged, it means:

A. It has excess thermal energy

B. It has excess charge

C. It has equal numbers of protons and electrons

D. It has a larger mass

4. A body with an excess of electrons is:

A. Neutral

B. Positively charged

C. Negatively charged

D. Uncharged

5. Coulomb's law describes the relationship between:

A. Force and mass

B. Electric force and charges

C. Voltage and current

D. Magnetic field

6. The electric force between two point charges is directly proportional to:

A. The square of the distance

B. The product of the charges

C. The potential difference

D. Charge density

7. The electric force between two point charges is inversely proportional to:

A. Distance

B. The square of the distance

C. Voltage

D. Electric flux

8. The force between two positive charges is:

A. Attractive

B. Repulsive

C. Zero

D. Depends on the medium

9. The SI unit of Coulomb's constant (K) is:

A. N/m

B. $N \cdot m^2/C^2$

C. C/N

D. J/C

10. The approximate value of Coulomb's constant (K) is:

A. 9×10^9 $N \cdot m^2/C^2$

B. 8.85×10^{-12} F/m

C. 1.6×10^{-19} C

D. 3×10^8 m/s

11. A point charge means it is:

A. A very large charge

B. A charge distributed over a large area

C. A charge with very small dimensions compared to distance

D. A moving charge

12. Coulomb’s law applies to:

A. Only moving charges

B. Stationary point charges

C. Magnetic charges

D. Electric currents

13. The force between two unlike charges is:

A. Repulsive

B. Attractive

C. Zero

D. Depends on the potential

14. The superposition principle states that:

A. The total force equals the product of all forces

B. The total force equals the vector sum of all individual forces

C. Forces are independent

D. The largest force cancels others

15. The vector form of Coulomb’s law represents:

A. The direction and magnitude of force

B. Only potential

C. Distance between charges

D. Magnetic field

16. The volume charge density is defined by:

A. $\rho = dq/dV$

B. $\sigma = dq/dS$

C. $\lambda = dq/dL$

D. $q = \int \lambda \, dL$

17. The surface charge density is defined by:

A. $\rho = dq/dV$

B. $\sigma = dq/dS$

C. $\lambda = dq/dL$

D. $q = \int \rho \, dV$

18. The linear charge density is defined by:

A. $\lambda = dq/dL$

B. $\sigma = dq/dS$

C. $\rho = dq/dV$

D. $q = \int \sigma \, dS$

19. In Coulomb's law, the vector r_{12} represents:

A. Total force

B. The vector from q_1 to q_2

C. Absolute distance

D. Opposite direction

20. The law of conservation of charge states that:

A. Charge can be created or destroyed

B. Charge is conserved and cannot be created or destroyed

C. Charge converts to energy

D. Charge depends on temperature