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Intermediate
Electrostatics

Coulomb's Law

The force of attraction or repulsion between two charged bodies varies directly as the product of their charges and inversely as the square of the distance between them. The latter part of the law is known as the law of inverse square.

If F is the force of attraction or repulsion between two charges q_1, q_2 and r the distance between them,

$$F = K \frac{q_1 q_2}{r^2} \quad \text{------} \quad (1)$$

Where K is an arbitrary constant. We can choose any positive value of K. In S.I units, the value of K is about 9×10^9. The choice of K determines the size of the unit of charge. The unit of charge that results from this choice is called Coulomb. Putting this value of K in eqn (1), we see that for $q_1 = q_2 = 1C$, $r = 1m$.

$$F = 9 \times 10^9 N$$

That is, 1C is the charge that when placed at a distance of 1m from another charge of the same magnitude in vacuum experiences an electrical force of repulsion of magnitude 9×10^9 N. One Coulomb is evidently too big a unit to be used. In practice, in electrostatics, one uses smaller units like 1 mC or 1 μC.

The constant K in eqn. (1) is usually put as $K = \frac{1}{4\pi\epsilon_0}$. So, Coulomb's law is written as

$$F = \frac{1}{4\pi\epsilon_0} \cdot \frac{q_1 q_2}{r^2} \quad \text{---- (2)}$$

ϵ_0 is called the permittivity of free space.

The value of ϵ_0 in S.I units is

$$\epsilon_0 = 8.854 \times 10^{-12}\, C^2 N^{-1} m^{-2}$$