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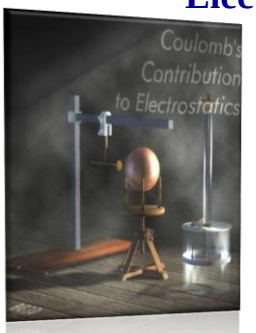
General Physics II

Electrostatic: Principles & Applications



Lecture (1): Coulomb's Law

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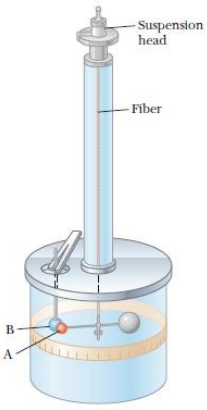
Charles Coulomb
1736 - 1806

Coulomb's Law

In 1785, Coulomb established the fundamental law of *electric force* between two stationary, charged particles. Experiments show that an electric force has the following properties:



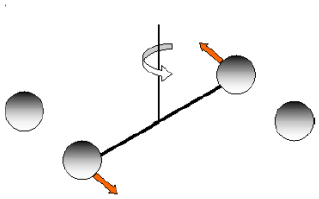
(1) The force is *inversely proportional* to the square of separation, r^2, between the two charged particles.

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

(2) The force is *proportional* to the product of charge q_1 and the charge q_2 on the particles.

$$F \propto q_1 q_2$$

(3) The force is *attractive* if the charges are of opposite sign and *repulsive* if the charges have the same sign.



We can conclude that

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

where K is the coulomb constant = 9×10^9 N.m^2/C^2.

The above equation is called *Coulomb's law*, which is used to calculate the force between electric charges. In that equation F is measured in Newton (N), q is measured in unit of coulomb (C) and r in meter (m).

The constant K can be written as

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

where ε_o is known as the *Permittivity constant of free space*.

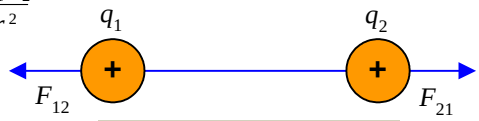
$\varepsilon_o = 8.85 \times 10^{-12}$ C^2/N.m^2

$$K = \frac{1}{4\pi\varepsilon_o} = \frac{1}{4\pi \times 8.85 \times 10^{-12}} = 9 \times 10^9 N.m^2/C^2$$

Coulomb's Law

The electrostatic force of a charged particle exerts on another is proportional to the product of the charges and inversely proportional to the square of the distance between them.

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



Repulsive force

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

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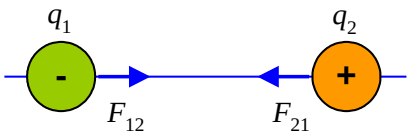
$$F_{12} = K \frac{q_1 q_2}{r^2} = F_{21}$$



Attractive force

Example 1

Calculate the value of two equal charges if they repel one another with a force of 0.1N when situated 50cm apart in a vacuum.

Solution

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

$$0.1 = \frac{9\times10^9 \times q^2}{(0.5)^2}$$

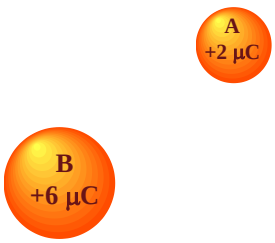
$$q = 1.7\text{x}10^{-6}\text{C} = 1.7\mu\text{C}$$

Quiz 1

One charge of 2.0 C is 1.5m away from a –3.0 C charge. Determine the force they exert on each other.

Quiz 2

Object A has a charge of +2μC and Object B has a charge of +6μC.
Which statement is true?



- **A:** $\mathbf{F}_{AB}=-3\mathbf{F}_{BA}$
- **B:** $\mathbf{F}_{AB}=-\mathbf{F}_{BA}$
- **C:** $3\mathbf{F}_{AB}=-\mathbf{F}_{BA}$
- **D:** $\mathbf{F}_{AB}=12\mathbf{F}_{BA}$