## 1. Coulomb's Law

Coulomb's Law states that the electrostatic force between two **point charges** is:

- **Directly proportional** to the **product** of the charges.
- **Inversely proportional** to the **square of the distance** between them.

### Mathematical Expression:

$F = k\frac{q_1 q_2}{r^2}$ where:

- $F$ = Electrostatic force (Newton, **N**)
- $q_1, q_2$ = Magnitudes of charges (Coulomb, **C**)
- $r$ = Distance between charges (meters, **m**)
- $k$ = Coulomb's constant (**9 × 10^9 Nm²/C²**) in vacuum

### Key Points:

- **Like charges repel**, unlike charges attract.
- **Force is along the line** joining the charges.
- **Works best for point charges** or spherical distributions.
- **Medium affects force**: Different materials reduce or enhance electrostatic force.

## 2. Significance of Medium in Coulomb's Law

The medium between charges affects the force due to its **dielectric constant** ($\varepsilon_r$).

$F_{medium} = \frac{1}{4\pi\varepsilon_0\varepsilon_r} \times \frac{q_1 q_2}{r^2}$

where $\varepsilon_r$ is the **relative permittivity** (dielectric constant) of the medium.

### How Medium Affects Electrostatic Force?

- **Vacuum/Air**: $\varepsilon_r = 1$, maximum force.
- **Water**: $\varepsilon_r = 80$, force is reduced by 80 times.
- **Glass**: $\varepsilon_r = 4 - 10$, moderate force reduction.
- **Metals**: $\varepsilon_r \to \infty$, force inside conductors is nearly zero (shielding effect).

🔹 **Higher dielectric constant → Weaker electrostatic force.** 🔹 **This principle is used in capacitors and insulation materials.**

## 3. Understanding Dielectric Constant in Simple Terms

Think of **dielectric constant** as how much a material weakens the force between charges.

- **Vacuum/Air** ($\varepsilon_r = 1$) → No weakening, full force.
- **Water** ($\varepsilon_r = 80$) → Weakens force by 80 times.
- **Glass** ($\varepsilon_r \approx 4 - 10$) → Weakens force moderately.
- **Metals** ($\varepsilon_r \to \infty$) → Force is almost zero (used for shielding, e.g., Faraday cage).

📌 **Analogy:**

- Talking in an **empty room** (vacuum) = voice is clear.
- Talking in a **crowded room** (water) = voice is weak.
- Talking in a **semi-crowded room** (glass) = voice is reduced, but not completely.

**In summary, dielectric constant = how much a material reduces electrostatic force.**

## 4. Theory of Quantization of Charge

The **quantization of charge** means that charge always exists in discrete multiples of the elementary charge 'e' (1.6 × 10^-19 C).

**Formula:**

$Q = n \times e$ where:

- $Q$ = total charge,
- $n$ = integer (±1, ±2, ±3...)
- $e$ = charge of an electron (1.6 × 10^-19 C)

🔹 **No fraction of charge can exist.** 🔹 **Every charge in the universe is a whole-number multiple of this fundamental charge.** 🔹 **Example:** If a body has a charge of -3e, it means it has an excess of **3 electrons.**

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## 5. Quiz Time! 📝

**MCQs on Coulomb's Law:**

1. Coulomb's Law is applicable to: a) Only small charged bodies b) Only neutral bodies c) Point charges at rest d) Moving charges
2. The force between two charges is **inversely proportional to**: a) Product of charges b) Distance between them c) Square of the distance between them d) Medium's dielectric constant
3. If the distance between two charges is **tripled**, the force becomes: a) 9 times stronger b) 9 times weaker c) 3 times stronger d) 3 times weaker

**Fill in the Blanks:**

1. The SI unit of charge is ________.
2. Coulomb's Law states that the force between charges is _______ **proportional** to the square of their separation.
3. In vacuum, the value of Coulomb's constant is _______ **$Nm^2/C^2$**.
4. The force between two charges in water is _______ **times weaker** than in air.
5. The charge of a proton is _______ **C.**

**Match the Following:**

| Column A | Column B |
|---|---|
| Coulomb's Law | Electrostatic Force |
| Dielectric Constant | Reduces force between charges |
| Charge Quantization | Discrete multiples of e |
| Force between two charges | Inversely proportional to distance squared |
| Vacuum permittivity | $8.85 \times 10^{-12}$ $C^2/Nm^2$ |

📚 **Now, complete your assignment!** 😄 ⚡

## Example

Two 0.5 kg spheres are placed 25 cm apart. Each sphere has a charge of 100 μC, one of them positive and the other negative. Calculate the electrostatic force between them, and compare it to their weight.

Coulomb's Law: $|F| = \frac{k\,|q_1|\,|q_2|}{r^2} \quad k = 9 \times 10^9\ N\,m^2\,C^{-2}$

$$|q_1| = |q_2| = 100\ \mu C = 100 \times 10^{-6}\ C = 10^{-4}\ C$$

$$r = 25\ cm = 0.25\ m$$

$$F_{electrostatic} = \frac{9 \times 10^9 \times 10^{-4} \times 10^{-4}}{0.25^2} = 1440\ N$$

$$F_{weight} = mg = 0.5 \times 9.8 = 4.9\ N$$

# Electrostatic force

- The electrostatic force is a vector, written $\vec{F}$
- Vectors have a magnitude and a direction. This may be indicated by components $\vec{F} = (F_x, F_y, F_z)$
- The magnitude is sometimes written as $|\vec{F}|$. It can be evaluated as $|\vec{F}| = \sqrt{{F_x}^2 + {F_y}^2 + {F_z}^2}$
- The direction can be indicated by a unit vector