Electrostatics

Coulomb's Law

Gravitational Force

$$F_g = \frac{Gm_1m_2}{r^2}$$

- F_g = gravitational force (N)
- G = Universal gravitational constant = 6.67×10^{-11} Nm^2/kg^2
- m_1 and m_2 = masses (kg)
- r = distance between the center of the masses (m)

ELECTROSTATICS (AKA Static Electricity)

- Ordinary matter is made up of neutrons, protons, and electrons.
- The most important opening idea, electrically, is that protons and electrons have a property called "charge" which is the same size, but opposite in polarity.
- The proton has 1836 times the mass of the electron, but exactly the same size charge, only positive rather than negative.

Important Info

Particle		Mass (Kg)	Charge (C)
n^0	neutron	1.67×10^{-27}	0
p^+	proton	1.67×10^{-27}	$+1.6 \times 10^{-19}$
e^-	electron	9.11×10^{-31}	-1.6×10^{-19}

ELECTROSTATICS (AKA Static Electricity)

- Even the terms "positive" and "negative" are arbitrary, but well-entrenched historical labels.
- The essential implication of that is that the proton and electron will strongly attract each other and two protons or two electrons will strongly repel each other;
- "like charges repel and unlike charges attract".

Conservation of Charge

- One of the fundamental properties of nature is the conservation of electric charge.
- Charge tends to be naturally transferred between unlike charges.
- There are three ways to transfer charge: friction, induction, and conduction.

Transfer of Charge

- Friction: two neutral objects are rubbed against each other and one becomes negative and the other positive.
- Induction: Bring a charged object near a neutral object and the neutral object becomes oppositely charged.
- Conduction: Touch a neutral object with a charged object and the neutral object becomes similarly charged

Coulomb's Law

- The electric force between two charges is proportional to the product of their charges and inversely proportional to the square of the distance between the charges.

$$F_e = \frac{K|q_1||Q_2|}{r^2}$$

F_e = electric force (N)

K = electric constant = 9×10^9 Nm^2/C^2

q_1 Q_2 = charges (Coulombs, C)

r = distance between charges (m)

Sample

- What is the electric force between a 3μC charge and a -5μC charge that are separated by 4.2 E-3 m?

$$\boldsymbol{F_e = K\frac{|q_1 Q_2|}{r^2}}$$

$$\boldsymbol{F_e = 9E9\frac{Nm^2}{C^2}\frac{|(3E-6C)(-5E-6C)|}{(4.2E-3m)^2}}$$

$$\boldsymbol{F_e = 7{,}653N}$$

Practice

Two charges a -6 μC charge and a 10 μC charge experience a force of 645 N. What is the distance between the charges?

$$\boldsymbol{F_e = K\frac{|q_1 Q_2|}{r^2}}$$

$$645N = 9E9\frac{Nm^2}{C^2}\frac{|(-6E-6C)(10E-6C)|}{r^2}$$

$$r = 0.029m$$

Practice

Two charges one 5 μC and the other is 7 μC are separated by a distance of 5.3 E -4 m. What is the electric force between these two charges?

$$\boldsymbol{F_e = K\frac{|q_1 Q_2|}{r^2}}$$

$$F_e = 9E9\frac{Nm^2}{C^2}\frac{|(5E-6C)(7E-6C)|}{(5.3E-4m)^2}$$

$$F_e = 1.12E6N$$