



Flipping Physics Lecture Notes:
AP Physics 1 Review of *Electrostatics*

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Elementary Charge: The smallest charge of an isolated particle. $e = 1.6 \times 10^{-19} \text{ C}$

- Two examples: $q_{\text{electron}} = -e = -1.6 \times 10^{-19} \text{ C}$ & $q_{\text{proton}} = +e = +1.6 \times 10^{-19} \text{ C}$

The electron is a fundamental particle, however, the proton is not a fundamental particle.

Protons and neutrons are composed of “up” and “down” quarks: $q_{\text{up quark}} = +\frac{2}{3}e$ & $q_{\text{down quark}} = -\frac{1}{3}e$

- Proton is composed of 2 “up” quarks and 1 “down” quark.
 - $q_{\text{proton}} = 2q_{\text{up quark}} + 1q_{\text{down quark}} = 2\left(+\frac{2}{3}e\right) + \left(-\frac{1}{3}e\right) = +\frac{4}{3}e - \frac{1}{3}e = +e$
- Neutron is composed of 1 “up” quark and 2 “down” quarks.
 - $q_{\text{neutron}} = 1q_{\text{up quark}} + 2q_{\text{down quark}} = \left(+\frac{2}{3}e\right) + 2\left(-\frac{1}{3}e\right) = +\frac{2}{3}e - \frac{2}{3}e = 0$
- A quark can have a charge less than the Elementary Charge because a single quark has never been isolated; quarks are always found in groups like they are in the proton and neutron.

The Law of Charges: Unlike charges attract and like charges repel. For example:

- Two positive charges repel one another & two negative charges repel one another.
- A positive and a negative charge attract one another.

The force they repel or attract one another with is determine using Coulomb’s Law: $F_e = \frac{kq_1q_2}{r^2}$

- This is called the Electrostatic Force. (Also sometimes called a Coulomb Force)
- Coulomb’s Constant, $k = 8.99 \times 10^9 \frac{\text{N} \cdot \text{m}^2}{\text{C}^2}$
- q_1 & q_2 are the charges on the two charged particles.
- r is not the radius, it is the distance between the centers of charge of the two charges. (Sometimes r actually is the radius, however, that is not its definition.)
- Note the similarity to Newton’s Universal Law of Gravitation: $F_g = \frac{Gm_1m_2}{r^2}$
 - However, comparing Coulomb’s Constant to $G = 6.77 \times 10^{-11} \frac{\text{N} \cdot \text{m}^2}{\text{kg}^2}$ shows that Coulomb’s Constant is about 10^{20} times greater than the Gravitational Constant. In general, the electrostatic force is much, much, much greater than the gravitational force.

Conservation of Charge: In an isolated system the total charge stays constant. For example, if we start with two electrically isolated spheres, $q_{1i} = +4\text{C}$ & $q_{2i} = -2\text{C}$, we touch them together and pull them apart:

$$q_t = q_{1i} + q_{2i} = +4\text{C} + (-2\text{C}) = +2\text{C} \quad \& \quad q_{1f} = q_{2f} = q_f \Rightarrow q_t = q_{1f} + q_{2f} = q_f + q_f = 2q_f \Rightarrow q_f = \frac{q_t}{2} = \frac{+2\text{C}}{2} = +1\text{C}$$

Each sphere ends up with 6.24×10^{18} excess protons on it:

$$q_1 = n_1 e \Rightarrow n_1 = \frac{q_1}{e} = \frac{+1\text{C}}{1.6022 \times 10^{-19} \text{ C} / \text{proton}} \approx 6.24 \times 10^{18} \text{ protons}$$