Notes on Electromagnetism

Giacomo

September 16, 2025

Class Information

Recommended Textbooks

- The Feynman Lectures on Physics
- Picasso - Lezioni di fisica

1 Coulomb's Law

Coulomb's law describes the electrostatic force between two charged particles. The force $\mathbf{F}_{12}$ exerted by a charge q_1 on a charge q_2 is given by:

$$\mathbf{F}_{12} = k\frac{q_1 q_2}{R^2}\hat{\mathbf{R}}_{12} \tag{1}$$

where k is Coulomb's constant, R is the distance between the charges, and $\hat{\mathbf{R}}_{12}$ is the unit vector pointing from q_1 to q_2. The force exerted by q_2 on q_1 is equal and opposite:

$$\mathbf{F}_{12} = -\mathbf{F}_{21} \tag{2}$$

Coulomb's constant k is defined as:

$$k = \frac{1}{4\pi\epsilon_0} \tag{3}$$

where ϵ_0 is the permittivity of free space.

2 2019 Redefinition of SI Base Units

Since 2019, the SI base units are defined by setting the numerical values of seven defining constants. This includes the elementary charge, e. As a result, the vacuum permittivity ϵ_0 is no longer a defined constant but is a measured value with an associated uncertainty. This is a change from the pre-2019 definition where ϵ_0 was an exact value.

The redefinition emphasizes the fundamental constants of nature. For example, the gravitational force F_G and the electric force F_E can be compared:

$$F_G = G\frac{m_p m_e}{R^2} \approx 10^{-47} N \tag{4}$$

$$F_E = \frac{1}{4\pi\epsilon_0}\frac{e^2}{R^2} \approx 10^{-7} N \tag{5}$$