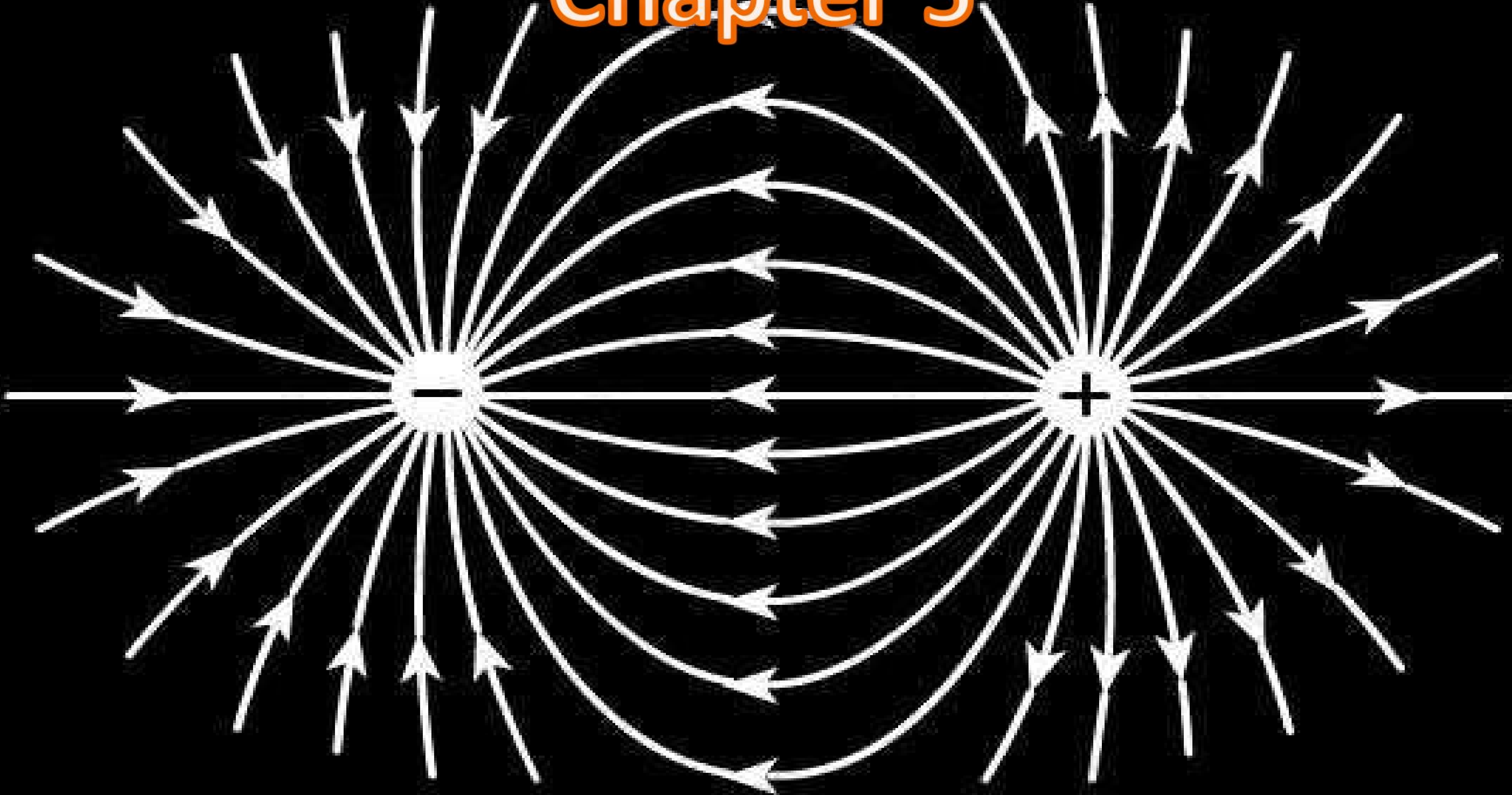
Chapter 5



The electrostatic field in a vacuum

primary coverage

1 Coulomb's law

2 Electrostatic field
Electric field intensity

3. Gauss's law

4. Electric potential

§ 5.1

Coulomb law

5.1.1 Charge

1. The kind of electric charge

   There are both positive and negative charges in nature

   Like charges repel; unlike charges attract.

2. The quantization of the electric charge

   In nature, the charge Q always appears as an integer multiple of the defined basic unit e.

$$q = ne \qquad (n = 1, 2, 3, \cdots)$$

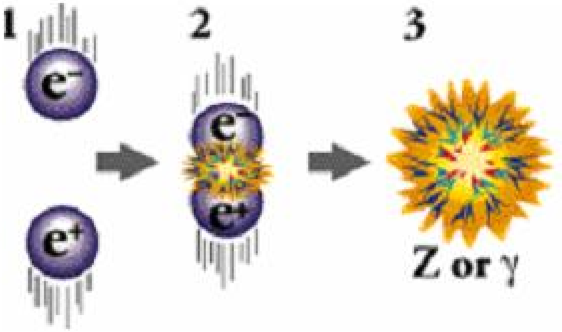
$$e = 1.602\,176\,487 \times 10^{-19}\,\mathrm{C}$$

Modern physics theoretically predicts that elementary particles consist of several quarks or antiquarks, and each quark or antiquark may have ± ⅓ e or ± ⅔ e of electricity, but the separate quark has not yet been found experimentally.

The quark model was proposed by the American physicist Murray Gell-Mann (1929-) in 1964

3. Law of conservation of charge

In isolated systems, the algebraic sum of the charge remains constant.
(One of the fundamental laws of conservation of nature.)
The law of charge conservation applies to both macroscopic and microscopic processes



The annihilation and production of positive and negative electron pairs

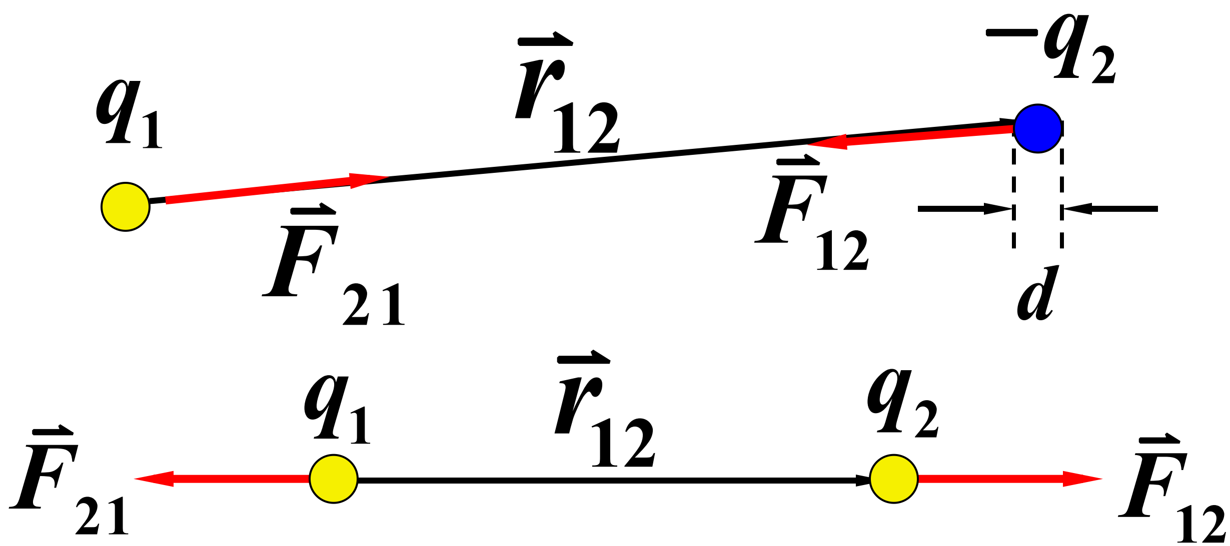
4. Relativistic invariance of the charge quantities

The power quantity of the isolated system is independent of its motion state.

5.1.2 Coulomb`s Law

Point charge model

1. The Coulomb's law in a vacuum $d \ll r_{12}$



$$\vec{F}_{12} = k\frac{q_1 q_2}{r_{12}^2}\vec{e}_{12} = -\vec{F}_{21}$$

SI make $k = 8.98755 \times 10^9\,\mathrm{N \cdot m^2 \cdot C^{-2}}$

$$\vec{F}_{12} = k\frac{q_1 q_2}{r_{12}^2}\vec{e}_{12} = -\vec{F}_{21}$$

◆a surname $k = \dfrac{1}{4\pi\varepsilon_0}$ (ε_0 Vacuum capacitance ratio)

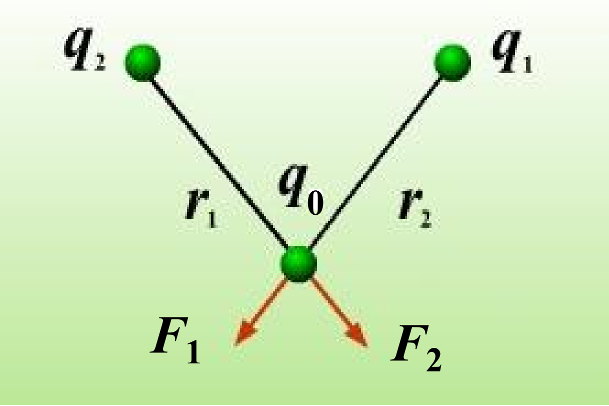
$$\varepsilon_0 = \frac{1}{4\pi k} = 8.8542\times10^{-12}\,\mathrm{C}^2\cdot\mathrm{N}^{-1}\cdot\mathrm{m}^{-2}$$

$$= 8.8542\times10^{-12}\ \mathrm{F}\cdot\mathrm{m}^{-1}$$

$$\boxed{\vec{F}_{12} = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r_{12}^2}\vec{e}_{12}}$$

2. The superposition principle of the Coulomb`s force

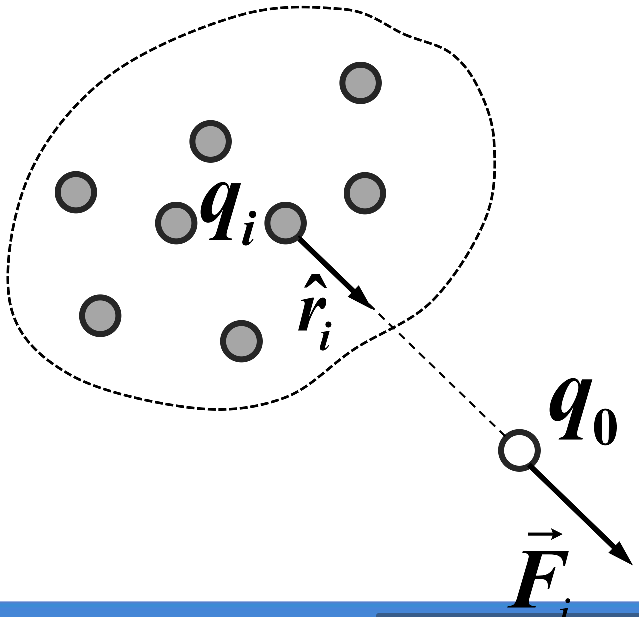
When more than two charges are present, they only exist between seperate two roles, i. e



$$\vec{F}_i = \frac{1}{4\pi\varepsilon_0}\frac{q_i q_0}{r_i^2}\hat{r}_i$$

$$\vec{F} = \vec{F}_1 + \vec{F}_2$$

The total force of a point charge is equal to the vector of the force on the point charge when the other point charge exists alone



$$\vec{F} = \sum_i \vec{F}_i = \frac{1}{4\pi\varepsilon_0}\sum_i \frac{q_i q_0}{r_i^2}\hat{r}_i$$