PHYS 111
1^{ST} semester 1439-1440
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Lecture 2

Chapter 23: **Electric Fields**

- **23.1 Properties of Electric Charges**
  - There are two kinds of electric charges: **positive** and **negative.**
  - Charges of the **same** sign repel one another and charges with **opposite** signs attract one another.
  - Electric charge is always **conserved** in an isolated system.
  - The electric charge q is said to be **quantized.** That is, electric charge exists as discrete "packets," $q = Ne$, where N is some integer.

23.3 Coulomb's Law

- From Coulomb's experiments, we can generalize the following properties of the **electric force** between two stationary charged particles. The electric force
  - is inversely proportional to the square of the separation r between the particles and directed along the line joining them;
  - is proportional to the product of the charges $q1$ and $q2$ on the two particles;
  - is attractive if the charges are of opposite sign and repulsive if the charges have the same sign;
  - is a conservative force.

23.3 Coulomb's Law

- We can express **Coulomb's law** as an equation giving the magnitude of the electric force (sometimes called the *Coulomb force*) between two point charges:

$$F_e = k_e \frac{|q_1||q_2|}{r^2}$$

- where k_e is a constant called the **Coulomb constant**, and it depends on the choice of units. The SI unit of charge is the **coulomb** (C).

$$k_e = 8.9875 \times 10^9 \ \mathrm{N \cdot m^2/C^2}$$

23.3 Coulomb's Law

- **Coulomb constant** is also written in the form

$$k_e = \frac{1}{4\pi\epsilon_0}$$

- where the constant $_0$ is known as the **permittivity of free space** and has the value

$$\epsilon_0 = 8.854\,2 \times 10^{-12}\ \mathrm{C^2/N \cdot m^2}$$

- The smallest unit of charge *e* known in nature is the charge on an electron (-*e*) or a proton (+*e*) and has a magnitude $e = 1.602\,19 \times 10^{-19}\ \mathrm{C}$

Example 23.1 **The Hydrogen Atom**

The electron and proton of a hydrogen atom are separated (on the average) by a distance of approximately 5.3×10^{-11} m. Find the magnitudes of the electric force and the gravitational force between the two particles.

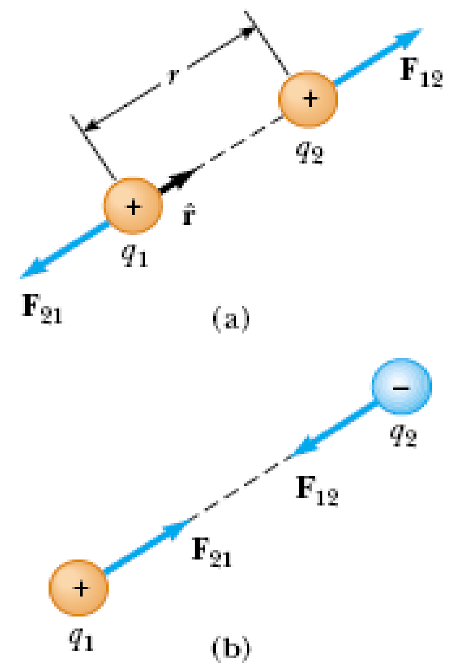
23.3 Coulomb's Law

- The law expressed in vector form for the electric force exerted by a charge q_1 on a second charge q_2, written $\mathbf{F}_{12}$, is

$$\mathbf{F}_{12} = k_e \frac{q_1 q_2}{r^2} \hat{\mathbf{r}}$$

  - where $\hat{\mathbf{r}}$ is a unit vector directed from q_1 toward q_2,
- The electric force exerted by q_2 on q_1 is equal in magnitude to the force exerted by q_1 on q_2 and in the opposite direction; that is, $\mathbf{F}_{21} = -\mathbf{F}_{12}$.

Vector form of Coulomb's law



23.3 Coulomb's Law

- When more than two charges are present, the force between any pair of them is given by Equation

$$\mathbf{F}_{12} = k_e \frac{q_1 q_2}{r^2} \hat{\mathbf{r}}$$

- Therefore, the resultant force on any one of them equals the vector sum of the forces exerted by the various individual charges. For example, if four charges are present, then the resultant force exerted by particles 2, 3, and 4 on particle 1 is

$$\mathbf{F}_1 = \mathbf{F}_{21} + \mathbf{F}_{31} + \mathbf{F}_{41}$$

Example 23.2 **Find the Resultant Force**

- Consider three point charges located at the corners of a right triangle as shown in Figure 23.8, where $q_1 = q_3 = 5.0$ μC, and $q_2 = -2.0$ μC, $a = 0.10$ m. Find the resultant force exerted on q_3.