Al-Mustaqbal University

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Department of Biology

Bio Physics

fifth lecture

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First Stage

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Conductive materials and insulating materials

1- Conductors are materials through which charge can move rather freely; examples include metals Examples of good conductors include copper, aluminum and silver

-Free electrons are not bound to the atoms.

-These electrons can move relatively freely through the material.

***2-* Insulators**: Electrical insulators are materials in which all of the electrons are bound to atoms. Examples of good insulators include glass, rubber and wood

-These electrons cannot move relatively freely through the material.

3-* Semiconductors*: The electrical properties of semiconductors are somewhere between those of insulators and conductors. include silicon and germanium.

The properties of **conductors** and **insulators** are due to **the structure and electrical nature of atoms**

-The protons and neutrons are packed tightly together in a central nucleus. -An electrically neutral atom contains equal numbers of electrons and protons.

Electrons are held near the nucleus because they have the electrical sign opposite that of the protons in the nucleus and thus are attracted to the nucleus.

-Most metals are good conductors, while most nonmetals are insulators. Within a solid metal such as copper,

-Some materials called semiconductors are intermediate in their properties between good conductors and good insulators.

2.3.1 Charging by Friction (Rubbing)

Electrons are transferred by rubbing from one material that becomes negatively charged to the other material becomes positively charged.

2.3.2 Charging by Contact

"Electrons are transferred from a negatively charged object to either a neutral or positively charged object by contact."

2.4 Coulomb's Law

If two charged particles are brought near each other, they each exert an **electrostatic force** on the other. The direction of the force vectors depends on the signs of the charges. If the particles have the same sign of charge, they repel each other. That means that the force vector on each is directly away from the other particle (Figure 2 a and b). If we release the particles, they accelerate away from each other. If, instead, the particles have opposite signs of charge, they attract each other.

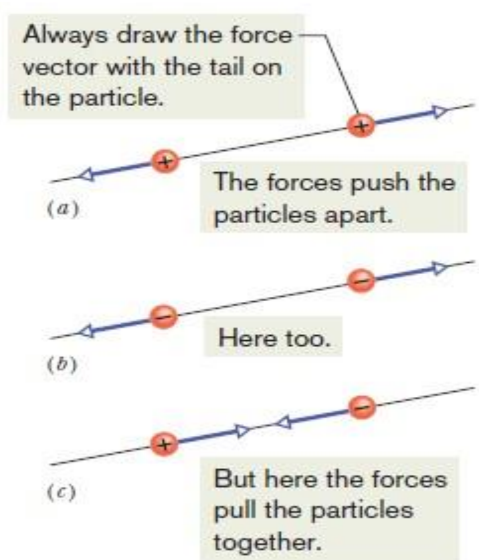


Figure 2: Two charged particles repel each other if they have the same sign of charge, either (*a*) both positive or (*b*) both negative. (*c*) They attract each other if they have opposite signs of charge.

Coulomb's law after Charles-Augustin de Coulomb, whose experiments in 1785 led him to it. Let's write the equation in vector form and in terms of the particles shown in Figure 3, where particle 1 has charge q_1 and particle 2 has charge q_2.

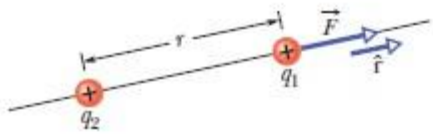


Figure 3: The electrostatic force on particle 1 can be described in terms of a unit vector along an axis through the two particles, radially away from particle 2.

Let's write the force acting on particle 1 in terms of a unit vector rˆ has a magnitude of exactly 1 and no unit that points along a radial axis extending through the two particles, radially away from particle 2. we write the electrostatic force as:

$$\vec{F} = k\frac{q_1 q_2}{r^2}\hat{r} \quad \text{(Coulomb's law)},$$

where *r* is the separation between the particles and *k* is a positive constant called the electrostatic constant or the Coulomb constant.

Unit. The SI unit of charge is the **coulomb**.

$$i = \frac{dq}{dt} \quad \text{(electric current)}.$$

Rearranging above and replacing the symbols with their units (coulombs C, amperes A, and seconds s) we see that:

$1\,C = (1\,A)(1\,s).$

Force Magnitude مقدار The electrostatic constant k is often written as $1/4\pi\varepsilon_0$ and The quantity ε_0, called the permittivity نفاذية constant.

$$F = \frac{1}{4\pi\varepsilon_0}\frac{|q_1||q_2|}{r^2} \quad \text{(Coulomb's law).}$$

$$k = \frac{1}{4\pi\varepsilon_0} = 8.99 \times 10^9\,\text{N}\cdot\text{m}^2/\text{C}^2.$$

$$\varepsilon_0 = 8.85 \times 10^{-12}\,\text{C}^2/\text{N}\cdot\text{m}^2.$$

Multiple Forces. Suppose we have n charged particles near particle 1, then the net force on particle 1 is given by the vector sum:

$$\vec{F}_{1,\text{net}} = \vec{F}_{12} + \vec{F}_{13} + \vec{F}_{14} + \vec{F}_{15} + \cdots + \vec{F}_{1n},$$

In which, for example, $\vec{F}_{14}$ is the force on particle 1 due to the presence of particle 4.

Examples:

1. Figure 4 *a* shows two positively charged particles fixed in place on an x axis. The charges are $q_1 = 1.60\times10^{-19}$ C and $q_2=3.2\times10^{-19}$ C, and the particle separation is R=0.02 m. **What are the magnitude and direction of the electrostatic force $\vec{F}_{12}$ on particle 1 from particle 2?**

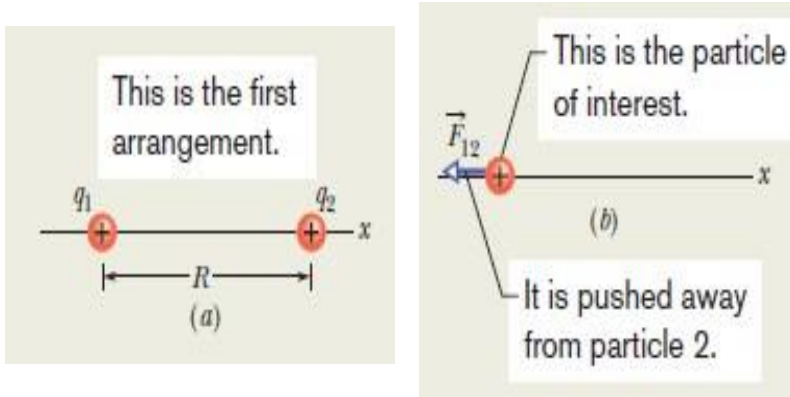


Figure 4: (*a*) Two charged particles of charges q_1 and q_2 are fixed in place on an *x* axis. (*b*), showing the electrostatic force on particle 1from particle 2.

Solution:

Because both particles are positively charged, particle 1 is repelled by particle

2. Thus, the direction of force $\vec{F}_{12}$ on particle 1 is *away from* particle 2, in the negative direction of the *x* axis, as indicated in Figure 4 *b*.

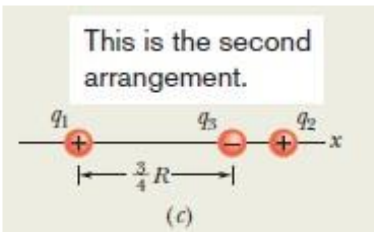
$$\begin{aligned} F_{12} &= \frac{1}{4\pi\varepsilon_0}\frac{|q_1||q_2|}{R^2} \\ &= (8.99 \times 10^9\ \mathrm{N\cdot m^2/C^2}) \\ &\quad \times \frac{(1.60 \times 10^{-19}\ \mathrm{C})(3.20 \times 10^{-19}\ \mathrm{C})}{(0.0200\ \mathrm{m})^2} \\ &= 1.15 \times 10^{-24}\ \mathrm{N}. \end{aligned}$$

With 180°

We can also write in unit-vector notation as:

$$\vec{F}_{12} = -(1.15 \times 10^{-24}\ \mathrm{N})\hat{\mathrm{i}}.$$

2. Figure 5 *c:* is identical to Figure 4 *a* except that particle 3 now lies on the x axis between particles 1 and 2. Particle 3 has charge $q_3 = -3.2 \times 10^{-19}$ C and is at a distance $\frac{3}{4}R$ from particle 1.**What is the net electrostatic force $\vec{F}_{1,net}$ on particle 1 due to particles 2 and 3?**



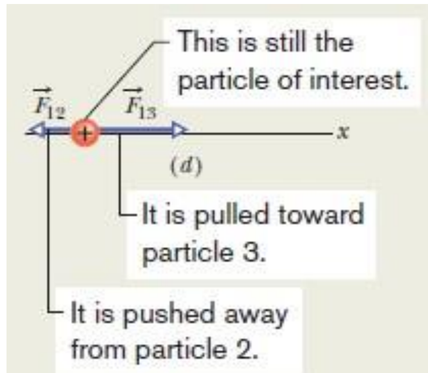


Figure 5: (*a*) Three charged particles of charges q_1, q_2 and q_3 are fixed in place on an x axis.

(*b*), showing the electrostatic force on particle 1from particle 2 and 3.

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