Phys 131 2022

Lecture 2

Weds: Discussion / quiz

* Do these before attending class

  132 Ex 1, 2, 3, 4, 5, 6, 7

* No need to turn in. but will discuss
* 10 minutes at end quiz – one question, like those on HW.

  – Must attend entire class to do quiz.
* Quiz counts 5pts (eventually grand total of 600 pts)

Thurs: Warm up 1 by 10 am

- Reading Quiz on D2L
- Show D2L page
- Two questions credit for any appropriate answer.
- More details Weds.

Fri: – Labs will happen

Electric charges + electrostatic forces

Certain objects have the inherent property that they are electrically charged, and that they can interact with other charged objects.

A can exert a force on any other charged object because it is charged. B can feel a force exerted by any other charged object because it is charged.

There are two types of charge: positive and negative and one basic rule describing their interactions is:

> Like charges repel each other
> Unlike charges attract each other.

We will eventually develop more precise language to describe the associated forces.

Origin of charge

A fundamental question is how materials become charged. In the ball and rod demonstration the charged of the rod and the ball could be made to vary and it even appears that charge can be transferred from one object to another.

The atomic picture of matter describes the origin of charge in terms of properties of basic subatomic particles.

1) electrons are always negatively charged by the same amount

$$\text{electron charge} = -e$$

2) protons are always positively charged by the same amount, which is exactly opposite to the electron charge

$$\text{proton charge} = +e$$

3) neutrons are neutral $\Rightarrow$ they have no charge.

$$\text{neutron charge} = 0$$

We can imagine any ordinary object as consisting of a large number of constituent electrons and protons and neutrons. We then define:

> The total charge of an object is the sum of all the charges of the individual constituent particles in the object

Usually an object will have the same (or very nearly) number of electrons as protons. Then the total charge of the object is zero. In this case we say that the object is electrically neutral.

Charge transport

We can actually move constituents from one object to another and in so we may be able to change the charge balance of objects. The extent to which this is feasible depends on the materials. The two extremes are:

1) conductors - electrons/charges move freely into/out of and throughout the material e.g. metal
2) insulators - electrons/charges can not move freely through the material e.g. rubber.

Charge conservation

An important observation is that in an isolated system charge cannot be created or destroyed. Precisely.

> If a system is isolated then the total charge of the system stays constant.

Conservation of charge

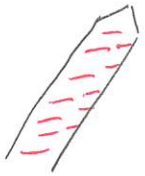
Explaining simple electrostatic phenomena

Demo: Rod / ball

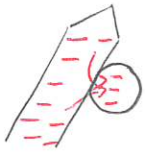
* Rub rod + hold near
* Touch ⇒ repel

We can explain this via:

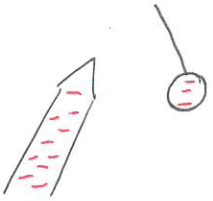
① Rubbing rod adds charge



② When the rod touches ball charges are transferred



③ Rod + ball have like charges + repel



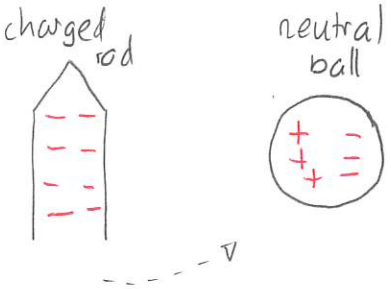
Quiz 1 80%

Demo: Do this with electroscope

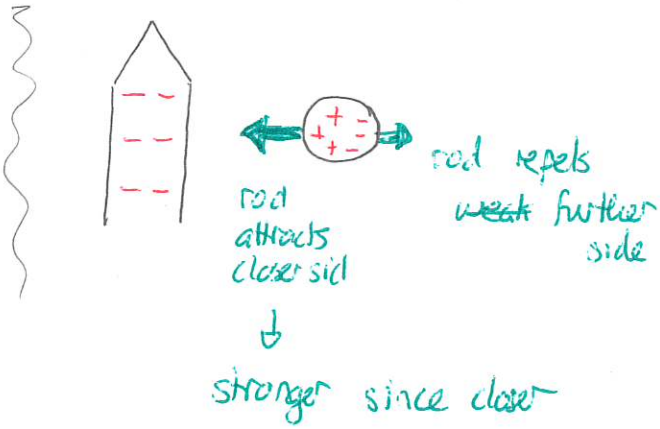
Polarization

In the rubbed rod + ball experiment, how did the rod initially attract the ball? We can explain this as:

Quiz 2: 50%



rod rearranges charges in ball ⇒ ball is polarized



Quantifying charge

The amount of charge that any charged object holds can be quantified, just as the mass of any object can be quantified. The exact scheme requires precise force laws. Eventually:

1) the basic unit of charge is a Coulomb (C)
2) the magnitude of the electron or proton charge is

$$e = 1.6 \times 10^{-19} C.$$

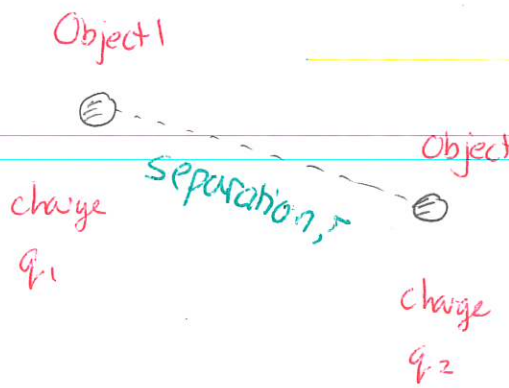
Thus the charge of an electron is $-1.6 \times 10^{-19} C$ and that of a proton is $+1.6 \times 10^{-19} C$.

Quiz 3

Coulomb's Law

The basic quantitative rule that governs all electrostatics is Coulomb's Law which gives the electrostatic force between two point charges.

Consider two point charges at rest relative to each other. Then the electrostatic force exerted by object 1 on object 2 has magnitude:



$$F_{1 on 2} = k \frac{|q_1||q_2|}{r^2}$$

where $k = 8.99 \times 10^9 \, Nm^2/C^2$ is Coulomb's constant

The direction of the force is along the line between the objects

Sometimes we write

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

where $\epsilon_0 = 8.85 \times 10^{-12} \, C^2/Nm^2$ is the permittivity of free space