Lecture 2

Weds: Warm Up 1 (D2L)

- show D2L 2pts out of eventual 624pts

Fri: HW by 5 pm

Exercises 2, 4, 6, 8, 10, 11, 15, 16

Phys 132L Labs Thursday

Phys 132 Survey - return by Friday

Electric charges and forces

Certain objects have the property that they are electrically charged. These can interact with each other via electric forces. There are two types of charge:

* positive
* negative

and a basic rule for interaction is

Like charges repel
Opposite charges attract

Quiz 1:

Origin of charge

Charge has its origin in the basic constituents of all matter:

1) electrons ⇝ negatively charged with magnitude "e" ⇝ electron charge = -e
2) protons ⇝ positively charged with " "e" ⇝ proton charge = +e
3) neutrons ⇝ zero charge (neutral) ⇝ neutron charge = 0

Ordinary objects consist of many electrons, protons and neutrons. Then

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

Atoms are frequently neutral and these have the same number of protons as electrons. Thus ordinary material has total charge zero, and is neutral.

Charge transport

Subatomic particles or portions of molecules can be moved between objects or through objects. The extent to which this occurs depends on the materials. Two extremes are:

1) conductors ⇒ electrons move freely through / into / out of material
   e.g. copper
2) insulators ⇒ electrons cannot move freely through / into / out of material
   e.g. rubber

Charge conservation

In an isolated system, charge cannot be created or destroyed. This is the law of the conservation of charge

> In an isolated system, the total charge of the system stays constant (as time passes).

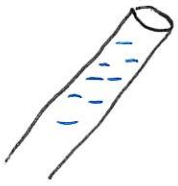
Qualitative explanations of simple electric phenomena

DEMO: Ball / rod

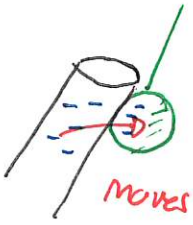
- rub rod + let touch → observe subsequent repulsion

This demonstration can be explained as:

① Rubbing the rod charges it



② When the ball touches the rod, charge moves from the rod to the ball



③ The rod + ball have like charges and repel

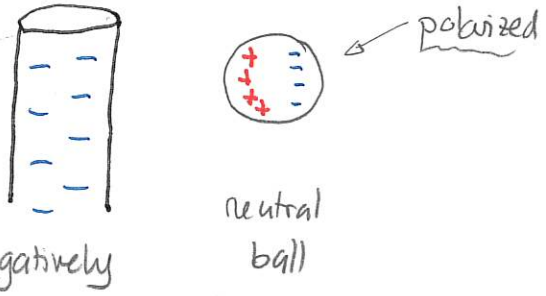
Quiz 2 50% – 70%

DEMO: DO Quiz 2 with electroscope

Polarization

The fact that the rubbed rod initially attracted the neutral ball can be described by a charge rearrangement called polarization.

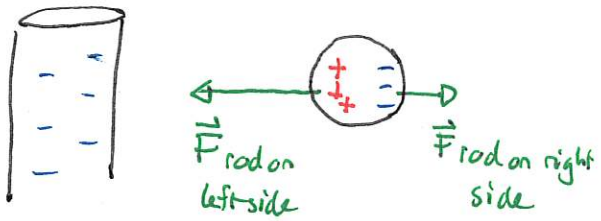
Earlier



↳ attracts positives in ball
repels negatives

Later

Quiz 3 70% –



stronger since left is closer.

⇒ net force on ball is $\vec{F}_{net}$

Quantifying charge

One can quantify the amount of charge on an object. This ultimately stems from the magnitudes of the charges of electrons and protons. After various experiments:

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

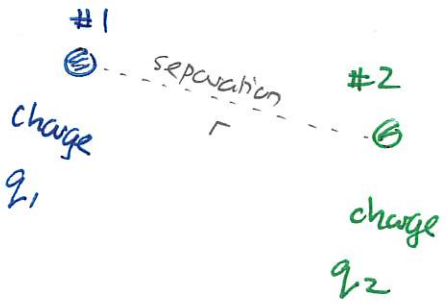
$$e = 1.602 \times 10^{-19} C$$

This allows us to determine the net charge of any object by adding the charges of all electrons and protons in the object.

Coulomb's Law

We can now provide the basic rule for the electric force exerted by a stationary point charge on another point charge. This is Coulomb's Law:

Consider two point charged particles that are at rest relative to each other. Then the electrostatic force exerted by #1 on #2:



* has magnitude

$$F_{1on2} = k \frac{|q_1||q_2|}{r^2}$$

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

* has direction along the line connecting the two charges.

The constant is often rewritten as

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

where

$$\epsilon_0 = 8{,}85 \times 10^{-12}\ C^2/Nm^2$$

is the permittivity of free space.

Important note: 1) charge is an inherent property of an object and only refers to one object.

2) charge of an object (that cannot transfer charge) is independent of its surroundings

3) force refers to what one object does to another and then describes the interaction between two objects