Lecture 2

Fri: HW by 5pm

Ex: 1, 2, 3, 4, 5, 6, 7, 8

Mon: Warm Up 2 by 10am

Electric charges and forces

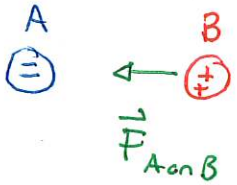
Some objects and particles are electrically charged. This means that they can interact via electric forces with other charged objects. There are two basic types of charge:

* positive charge
* negative charge

and these interact according to:

> Like charges repel.
> Opposite charges attract

We can use this plus some ideas about charging to explain qualitatively interactions between charged objects.



Origin of charge

Although many electric interactions between ordinary objects can be described without knowing the basic origins of charge it is useful to describe how charging arises using subatomic physics.

All atoms and matter consist of basic subatomic particles:

1) electrons these are always negatively charged by an amount with magnitude "e"

electron charge $= -e$

2) protons these are always positively charged with an amount of magnitude "e"

proton charge $= +e$

3) neutrons these have zero charge (called neutral)

neutron charge $= 0$.

Any ordinary object consists of many electrons, protons and neutrons. We can then say:

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

Neutral atoms always have the same number of protons as electrons, so ordinarily material will have total charge zero. In this case the object is electrically neutral.

Warm Up!

Charge transport

Subatomic particles or even portions of molecules can be moved between objects. This can affect the balance of charge. The extent to which this is feasible depends on the materials. Two extremes are:

1) conductors - electrons move freely through and onto or off the material Metals

2) insulators - electrons cannot move easily through and onto/off the material. Rubber.

Charge conservation

A fundamental principle of electromagnetism is that, in an isolated system, charge cannot be created or destroyed. This is the conservation of charge:

> In an isolated system, the total charge of the system stays constant.

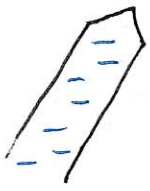
Qualitative explanations of simple electric phenomena

DEMO: Ball / rod

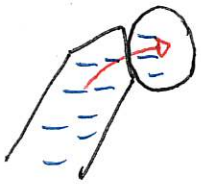
- rub rod touch
- observe repel

We explain this as:

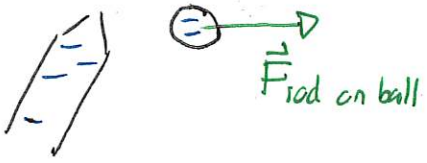
① Rubbing the rod charges it



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



③ The rod and ball have like charges and repel

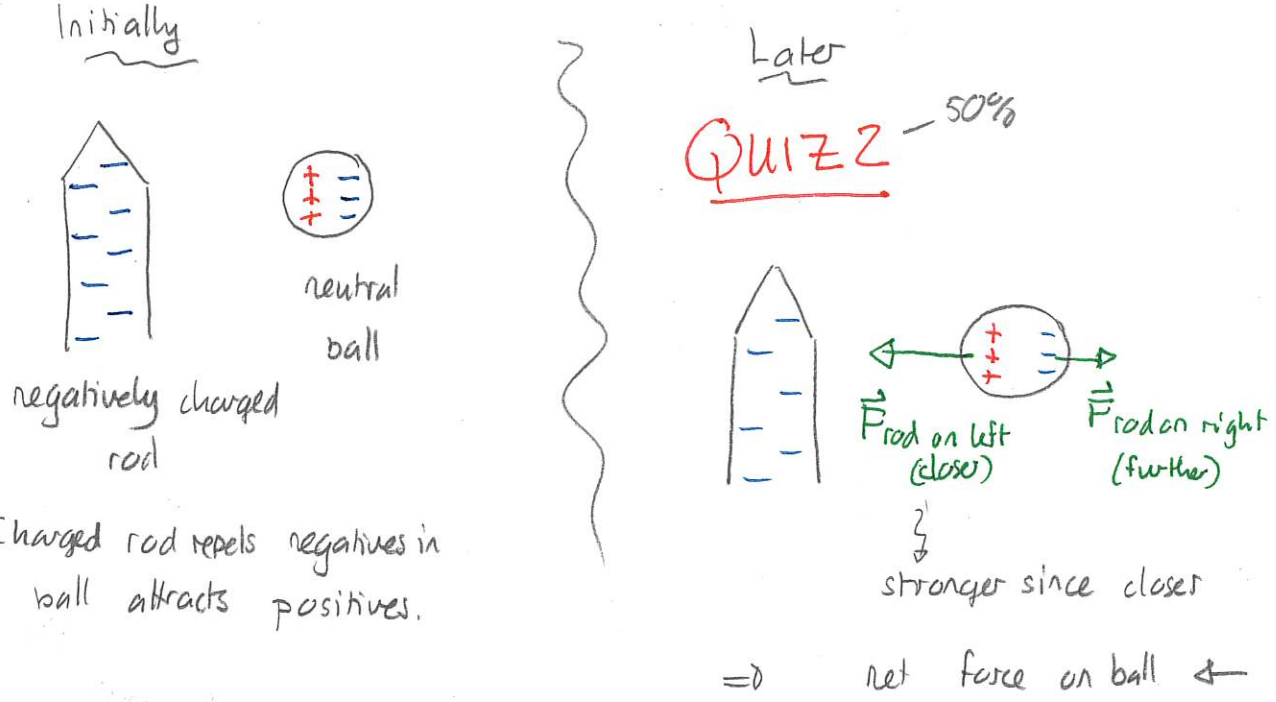


Quiz #1 30% - 70%

DEMO: Electroscope

Polarization

How did the rod in the demonstration attract the initially neutral ball? This can be explained by a rearrangement of charge called polarization



Quantifying charge

The amount of charge on a charged object can be quantified. The exact process actually uses force laws. Eventually we get:

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

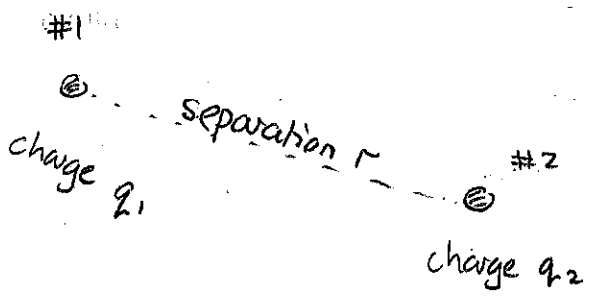
$$e = 1.609 \times 10^{-19} C$$

So the charge of an electron is $-1.609 \times 10^{-19} C$. The charge of a proton is $+1.609 \times 10^{-19} C$.

Coulomb's Law

The basic rule that governs all electrostatics (forces produced by stationary charges) is Coulomb's Law:

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



* has magnitude

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

where $k = 8.99 \times 10^{-9}\ Nm^2/C^2$ is Coulombs constant

* direction along the line between the charges

Often we rewrite the constant

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

where

$$\epsilon_0 = 8.85 \times 10^{-12}\ C^2/Nm^2$$

is a constant called the permittivity of free space