ELECTRICAL CHARGES

There are many different types of forces in nature. In previous lectures we have studied about the gravitational force. The strength or magnitude of this force depends on the 'amount ' or quantity of the objects between which the force exists. Furthermore, this force is purely attractive. Gravitational objects always attract each other. In contrast consider the experiment performed here with a glass rod plus silk cloth and pith balls. In this experiment also:

- the force depends on the 'amount' - the greater the number of times the rod is rubbed the greater the force.
- however, this force can be both repulsive and attractive
- So are there two different types of matter or 'stuff' involved here ?
- What is this 'stuff' anyway ?

We call this "charge". There are two types of charges '+' and '-'.

Questions about 'Charge":

- What is 'charge' - when the glass rod is touched to the pith ball are little pieces of the glass transferred to the pith ball?
- Is this charge visible to the naked eye or in some kind of microscope ?

Some Answers: Based on experiments performed aver the last two hundred years we now know (or accept) that all matter - including the teflon or glass rod, the silk cloth etc. are made of "atoms ". In fact glass is made of different types of atoms - a fact we know primarily from Chemistry. All atoms have electrons that spin around a nucleus. These electrons are fairly far away from the nucleus such that the atom is mostly empty - while the radius of an atom is of the order of 1 angstrom that of the nucleus is 10,000 times smaller. The electrons also have a mass - so does the nucleus. The fact that the electrons go around the nucleus implies (from Newtons laws - although electrons are 'microscopic' objects and therefore strictly speaking Newtonian mechanics does not apply) that there is a force of attraction. This is not due to the gravitational force but is due to a second attribute of matter - in addition to mass all matter also has 'charge'. Electrons by convention have a -ve charge and the nucleus has a +ve charge. The atom on the whole is electrically neutral. Since the electrons are so far away - it is relatively easy to dislodge them from their orbits in certain materials. Thus by the mere process of mechanical friction electrons can be transferred from silk to teflon and then onto the pith ball. When an electron leaves it's place it leaves behind an "ion".

Unit of Charge: is called a "Coulomb". An electron as determined from experiments has a charge of 1.6×10^{-19} C. A proton (which sits in the nucleus) has the **same** magnitude of charge - as far as we can tell.

Facts about Charge:

- There are two types of charges. Therefore both attraction and repulsive effects are possible. Like charges repel and unlike charges attract.

- Charge is conserved. This means we cannot 'annihilate' or 'remove' electrons from the universe. We have to remove a +ve charge also at the same time. This concept may be a little hard to grasp but has many consequences. For instance, you are able to watch TV because electrons are constantly being shot at the chemical coating on the back side of the TV screen. Yet you do not get a shock when you touch the screen. This does not mean that electrons that hit the screen after they have done their job (of giving out light) disappear. They are just recycled inside the TV ! The fact that charge is conserbed can also be concluded from another class demo - charging of two metal spheres with opposite charges by induction.

  Question: The charged pith balls stop repelling after some time. What happens to the charge on it ?

- Charge is quantized. How do we know this ? Can we look under a microscope and 'see' each electron and say you can only have so many Coulombs on you ? The first direct experimental proof that charge is discrete was given by Robert Millikan.The 'oil-drop experiment'.

- How does one measure charge ? With an instrument called an "electroscope" or another called an "electrometer". A "Faraday Cage" is an electroscope.

Electrostatics is the subject of static charges and the forces between them.

Electricity is the subject that deals with charges in motion. When charges (either +ve or -ve) move we have an electrical 'current'. The flow of charges in many ways is analogous to the flow of water in a pipe.

Unit of current - current is measured in 'Amperes'.

1 ampere = 1 coulomb of charge flowing per second = 1 C / 1 s

Convention: Current always moves in the direction opposite to the flow of electrons.

Table : Range of Current Values

System	Current (A)
Electron beam in a TV	10^{-3}
Light Bulb	1
Auto Starter	100
Electrical Cable 1 cm^2 area	1000
Superconducting Cable	10^{7}