Lecture 4

2 SEP 2014

- moving on to Chapter 21 :
  Electric Change

Many modern devices depend on physics of electromagnetism (computers, TV, radio, cell phone, lighting)

So it is important to understand

History: Greeks knew about this force. They discovered that if amber (a fossilized tree resin) is rubbed, then bits of straw will jump to it. (In fact, Greek word for amber is ηλεκτρον electron). Much later, it was discovered that this attraction is due to an electric force

Even later, electric force was connected to magnetism + these understood to be different aspects of a single electromagnetic force.

- Interestingly, the EM force is far stronger than the G force, which helps to explain why everything on Earth is not merely clumped together at the center. That is, the EM force is repulsive in addition to being attractive, so that this repulsion is strong enough to act against the G force.

<u>Electric charge</u> is a characteristic intrinsic to every particle. I.e., every particle carries electric charge.

- In most scenarios, we don't notice electric charge b/c it is balanced, but it becomes noticeable when there is an imbalance of charge.

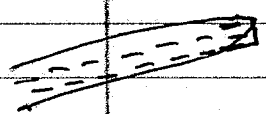
There are two kinds of charge: positive & negative (just taken by convention in one way)

E.g., can rub glass w/ silk to make it positively charged (i.e., removing negatively charged electrons)

- bringing two such charged pieces of glass towards each other leads to a

<u>repulsive</u> force (they push away from each other)

rub a plastic rod w/ fur & it becomes negatively charged.



the positive & negative will then attract

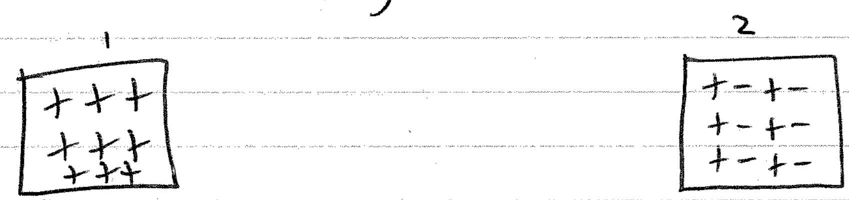
can quantify the strength of the electric force w/ Coulomb's law

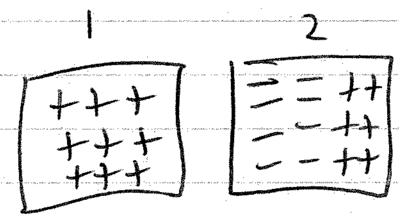
Benjamin Franklin chose the labels of "positive" & "negative"

<u>Conductors</u> – materials through which charge can move rather freely. (metals)

<u>Insulators</u> – materials ...... cannot move freely (rubber, plastic, glass)

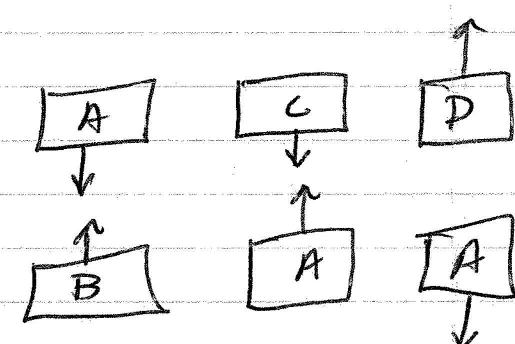
If we placed a charged object near a neutral object, then the neutral object will have its charge biased, i.e.





Question:

Given A, B, D charged & C neutral &

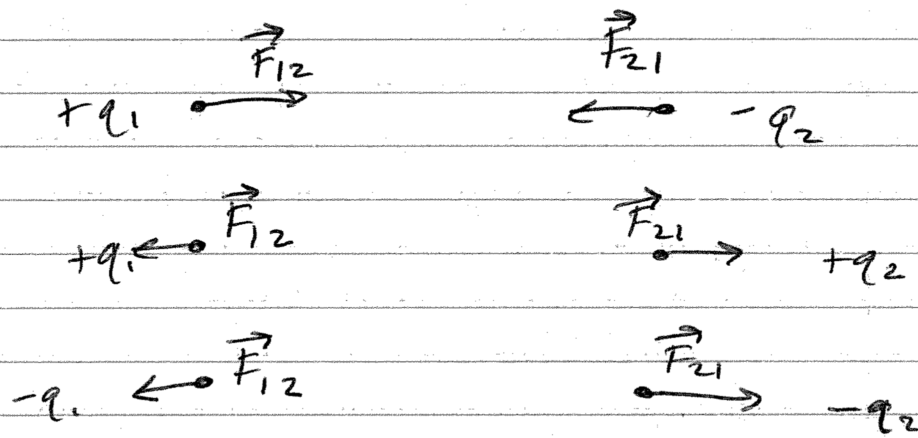


what will the force be between

C / D & B / D ?

Coulomb's Law for Electric Force

Force is either attractive or repulsive, depending on whether changes are the opposite or the same



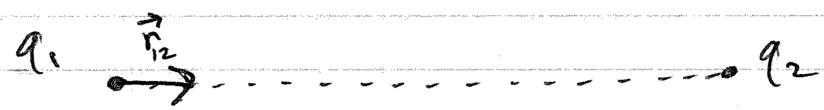
force is $\propto$ to $|q_1| \times |q_2|$

& inversely proportional to square of distance between them.

Another inverse square law...
(except signs of changes are very important)

Can write Coulomb's law as

$$\vec{F}_{12} = -k \frac{q_1 q_2}{r^2} \cdot \vec{r}_{12}$$



(we need the minus sign if the convention is that $\vec{r}_{12}$ is a unit vector pointing from q_1 to q_2.)

So we then have that

$$\vec{F}_{21} = -k \frac{q_1 q_2}{r^2} \cdot \vec{r}_{21}$$

w/ $\vec{r}_{21}$ a unit vector pointing from q_2 to q_1

q_1 is charge of particle 1 (measured in Coulombs - C)
q_2 " " " " 2

k is a constant (electrostatic) $= 8.99 \times 10^9 \; N \cdot m^2 / C^2$

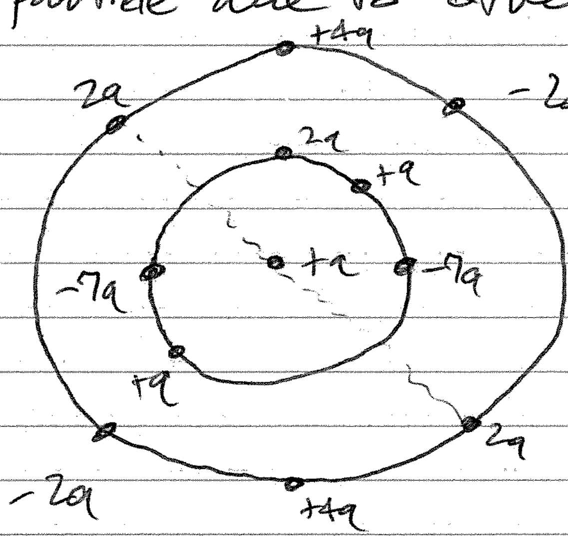
Principle of Superposition

To figure out the force on particle 1 due to others, calculate $\vec{F}_{12}, \vec{F}_{13}, \ldots, \vec{F}_{1n}$ & take vector sum

$$\vec{F}_{1,net} = \sum_i \vec{F}_{1i}$$

(similar to G-force case)

Question: What is net force on central particle due to others?



can work out similar examples as before...

Again there is a "shell" theorem. This is a consequence of inverse square law & principle of superposition.

1. A shell of uniform charge attracts or repels a charged particle as if all of the shell's charge is concentrated at its center.
2. If a charged particle is located inside a shell of uniform charge, then there is no net electrostatic force on the particle from the shell.