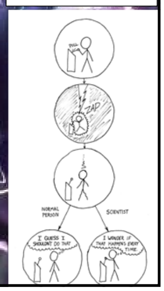
Chapter 4: The electromagnetic Interaction

Did you read chapter 4 before coming to class?

A. Yes
B. No



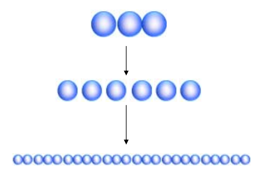
Review

- You take a block of ice to rock canyon park and slide down the hill on it. Analyze your motion from when you sit down on the ice at the top of the hill to when you come to a stop at the bottom. Include all forces, accelerations, and velocities that you experience during your slide. Also explain why you brought the block of ice.

A book is at rest on a table. The force paired with a book's weight (via Newton's third law) is:

A. The force exerted by the table on the floor
B. The force of gravity exerted by the book on the earth
C. The contact force of the table on the book
D. Cannot be determined without more information

The grand scheme of science



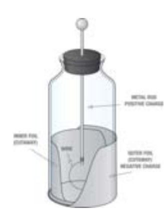
Goal: Understanding (to be able to predict the future)

Early observations

- The Greeks noticed by at least 600 B.C. that amber rubbed with fur could attract things.

(*Elektron*, amber in Greek)

Franklin hypothesized that a "fluid" was exchanged between the fur and the rod



Leyden Jar

Static electricity discharge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Last Update: Friday, September 16, 2005. 12:18pm (AEST)

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Man builds up 30,000 volts of static electricity

Victorian authorities believe a man built up at least 30,000 volts of static electricity in his jacket simply by walking around the western Victorian city of Warrnambool yesterday.

The man left a trail of scorch marks and molten plastic behind him.

It was yesterday afternoon when Frank Clewer walked into a Warrnambool business and got his first shock.

"It sounded almost like a firecracker or something like that," he said.

"It was at the reception area. Within say, around five minutes, the carpet started to erupt," he said.

Burns the size of 10-cent pieces were left on the carpet where Mr Clewer had been standing.

The Country Fire Authority evacuated the building and those around it, fearing the power could cause larger electrical problems.

But Mr Clewer's worries continued when he got back in his car.

"I actually scorched a piece of plastic I had on the floor of the car," he said.

Scientist Karl Kruszelnicki says it is likely the electrical build-up was caused by a number of factors, such as the synthetic clothes the man was wearing.

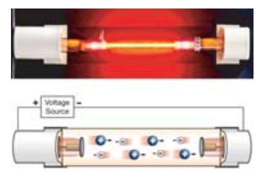
"This poor guy has built up static electricity thanks to an unfortunate combination of insulating clothes that he's wearing, static, synthetic clothes, just walking along and he's just building up this static charge everywhere," Dr Kruszelnicki said.

"I've read of it but I've never heard of it here in Australia."

The CFA has Mr Clewer's jacket and says it is continuing to give off voltage.

Is lightning the same stuff stored in a Leyden jar?

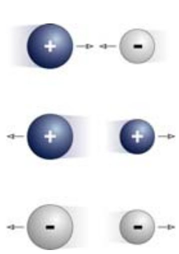
J. J. Thompson showed that Franklin's "fluid" model was not entirely correct.



- Matter is composed of positive and negative charged particles
- The positive parts of atoms have essentially the same mass as the atoms
- The negative parts all have the same mass, and behave the same for all substances.

Electrically charged objects attract or repel one another one another

- Like charges repel and opposite charges attract.
- The more "charged" the objects are, the stronger the interaction.
- The closer charged objects are, the stronger the interaction.



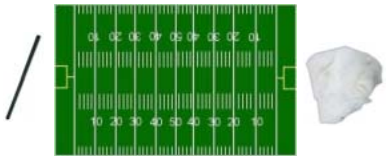
Coulomb quantified the electric force law

$$F = k\frac{Qq}{d^2}$$

- Familiar "inverse square" relationship.
- Q and q can be positive or negative (M and m could only be positive in gravity).
- k is much, much bigger than G, so the electrical interaction is much stronger than the gravitational interaction.


Charles-Augustin de Coulomb

An Example

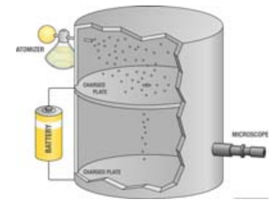


$$F = k\frac{Qq}{d^2}$$

Attractive force = 10^{13} Tons!!!

If the electromagnetic force is so strong, why don't we feel it?

The Millikan/Fletcher oil drop experiment provided conclusive proof that charges come in lumps



A note of interest to BYU, Harvey Fletcher

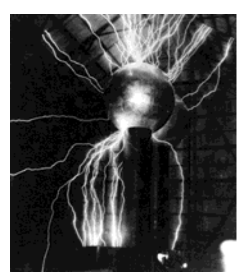
Summary

- The "+" and "-" labels came from Benjamin Franklin.
- Charge comes in discrete chunks or particles. The most common charge carrying particles (by far!) are electrons (e-) and protons (p+).
- e- and p+ charge magnitudes are the same but the p+ mass is 1836 times the e- mass.
  - So which one would accelerate the most when they attract each other?

Electric current: Charges in motion

- Generally the wire remains neutral, even though charge is flowing
- Resistance to flow causes energy loss
- DC is one way, AC alternates

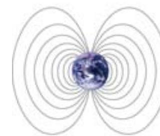
Let's play with electricity



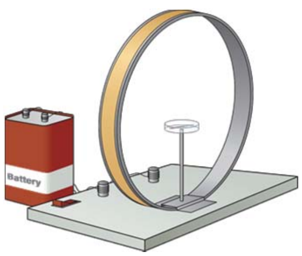
On to magnetism

Magnets produce a force on another magnet (and can induce magnetism in some materials)

- The direction of the force is a little more complicated than for electrically charged particles, but it still depends on distance between the magnets

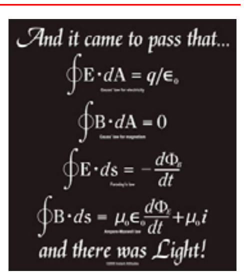


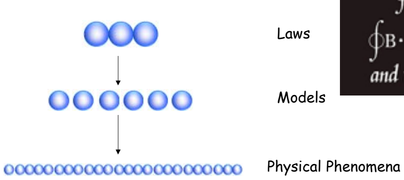
An electric current produces a magnetic field



Changing magnetic fields can produce moving charges. This is how we usually generate electric current.

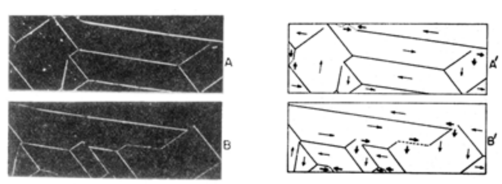
The grand scheme of science





Permanent Magnets

- Magnetism arises when the atoms (which act as tiny permanent magnets) align themselves in tiny domains.
- If you heat a magnet up, the domains can reorient (Curie Temperature)




Video Encyclopedia of
Physics Demonstrations
CURIE TEMPERATURE
Playing Time: 0:32